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WITH ABSTRACT OF THE LITERATURE

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Histopathology of Different Types of Electric Shock on Mammalian Brains

The Incidence of Illness among Wage Earning Adults

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THE JOURNAL OF INDUSTRIAL HYGIENE

VOLUME XII NOVEMBER, 1930 NUMBER 9

ARTERIAL HYPERTENSION IN INDUSTRY*

JAMES N. WYCHGEL, M.D., F.A.C.S.

From the Surgical Department, American Steel and Wire Company, Cleveland, Ohio

THIS paper has to do with hypertension in industrial employees over 54 years of age and with the problem of what advice to give the employer in respect to it.

In 1928, the writer conducted a physical examination of employees 55 years of age and over in one of the large plants of the American Steel and Wire Company, Cleveland, Ohio. One of the primary features of this examination was the determination of the blood pressure. Of 354 men examined, 73 per cent. were found to have hypertension, and the problem arose as to what to do with them. Both the employer and the men wanted to know whether they could continue with their work, whether their work should be made lighter, or whether they should be retired or pensioned. Some statements herein contained may seem to be dogmatic. They should not, however, be taken as final; the last word on the medical problem of hypertension has not yet been said. This is an effort to establish some basis for a solution of an industrial problem.

To define normal blood pressure is difficult, as the pressure in healthy persons varies considerably under different conditions. It has been taught for many years that the figure obtained by adding the age to 100 could be considered the normal for systolic pressure. This formula can still be used in establishing the normal systolic blood pressure up to the age of 50. After this age it should not be used because a persistent systolic pressure over 150, regardless of age, probably should be considered as pathologic; moreover, the examinations reported here show that after 55 years of age the average systolic pressure does not increase in that ratio.

With regard to the normal figure for diastolic pressure, there is some

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difference of opinion. The limit of normal is estimated by various writers at 90 to 100. All agree, however, that a pressure above 100 is pathologic. It has been the writer's experience that when the diastolic pressure is above 100 there is usually associated a rise in the systolic pressure to 150 or over. Of seventy-five men with a diastolic pressure exceeding 100 only five, or $6\frac{2}{3}$ per cent., had a systolic pressure of less than 150. If, then, 150 systolic and 100 diastolic are considered as the limits of normal, how shall men past these limits be classified, and what is their ability to work? In making such a classification the hazard in the type of work and the danger to others should be considered. The structural iron worker and the railway engineer should not be given as wide a latitude as the common laborer.

In considering the industrial problem of high blood pressure the primary concern is the blood pressure itself as a danger to the employee or to his fellows. The etiology or accompanying pathology and also the differentiation between primary, or essential, and secondary hypertension, while of interest, is not now under consideration.

Classification

It is evident that in order to obtain a practical working basis and to avoid vagueness, confusion, and misunderstanding, groupings by definite figures must be made. Because authorities differ as to limits of normal blood pressure, the following classification has been used:

First Degree Hypertension.—In which the systolic pressure ranges between 150 and 170, or the diastolic between 90 and 110, or both. In this class the systolic pressure only may be raised above normal. If, however, the increased systolic pressure persists, it is usually followed by a rise in the diastolic above normal. A systolic pressure of 170, not temporary in character, is probably the extreme limit of the range within which it is possible for the blood pressure to be reduced to normal.

This group comprises rather a large number of men. In the present series 47 per cent. were in this class. A great many of these men were not aware that there was anything wrong. The writer believes that if the work is not extra heavy they can continue with it, but they should be advised to seek medical aid; should be kept under observation and examined every six months; and if they do not improve under treatment in one year, should be considered as having second degree hypertension.

Second Degree Hypertension.—In which there is a persistent systolic pressure between 170 and 200, or a diastolic pressure of 110 to 120, or both. Twenty-two per cent. of the men examined were in this class.

In this group there is usually some degree of cardiac hypertrophy. It has been shown by autopsy that in cases where there has been a systolic blood pressure of 200 lasting one year or more, there is always cardiac hypertrophy. Probably a diastolic pressure of 120 is the extreme limit of working safety.

The members of this group should have a definite limitation of activity. They are no longer able to do heavy or responsible work. They should be carefully examined every six months for cardiac failure, as indicated by

cardiac enlargement, an increase in the pulse rate, irregularities of the pulse, alternating pulse, or by a drop in the systolic pressure although the diastolic may still be up.

In this class a permanent diastolic increase is usually associated with the systolic rise, and in such cases it is not to be expected that the blood pressure can be permanently reduced.

Third Degree Hypertension.—In which the systolic pressure is over 200, or the diastolic is over 120, or both. Four per cent. of the men examined were in this class.

Members of this group are unfit for work; they should be pensioned or placed in an occupation which requires no physical labor.

Some of these men die of apoplexy, but the majority (among workingmen) die of cardiac failure. From the industrial standpoint we are interested in death due to apoplexy because this may be and often is attributed to a man's occupation. The limit of time that persons with this degree of hypertension live is variously stated at from five to ten years. L. Hamman (1), in a study of a series of seventy-five cases in which there was a systolic pressure of 200 or over and a diastolic pressure of 110 or over, found that in 38 per cent. the patients were dead within two years, in 70 per cent. within five years, and in 100 per cent. within ten years.

Normal.—With a systolic pressure not over 150 and a diastolic pressure not over 90. Twenty-seven per cent. of the men examined were in this class.

This classification was developed from statistical data and personal observation to serve as a practical working basis. While statistical data have an important bearing on prognosis, in the individual case of hypertension it is a rash procedure to predict the length of life. There are many exceptions and it is well known that many persons who would have been classified under second degree hypertension have lived their normal expectancy.

Treatment

In considering the treatment, sight should not be lost of the fact that hypertension is a symptom and not a disease. The fundamental cause of hypertension is not known. There are certain factors which seem to bear a relation to the condition, such as overeating, fast living both mental and physical, heredity, kidney disease, and foci of infection. I agree with Rowntree (2) who says: "Because hypertension commonly occurs in nephritis and in association with arteriosclerosis the belief has become established that it is related to diseases of the kidney and to arteriosclerosis. A careful clinical analysis of many cases of this disease and, in recent years, the use of renal functional tests have served to dispel the idea that hypertension is, of necessity, due to either of these causes." Elimination of foci of infection and other associated pathology should always be carried out. This may or may not reduce the blood pressure, but at least it will have a beneficial effect on the general health of the patient. Most writers agree that the salt intake should be reduced. Numerous drugs, liver extracts, etc., have been and are being used with varying results. However, from the industrial standpoint, and also from the standpoint of the patient, it is essential to limit activity. Much

can be done for hypertension patients by furnishing them suitable work and by pensioning or otherwise retiring many who have third degree cases. When arterial hypertension was found in the men examined, they were advised of the fact (but were not given the figures) and were told to consult their family doctors.

TABLE 1.—FINDINGS CLASSIFIED ACCORDING TO DEGREE OF HYPERTENSION

DEGREE OF HYPERTENSION	NO. OF MEN	PERCENTAGE	AVERAGE AGE	AVERAGE SYSTOLIC	AVERAGE DIASTOLIC
First S 150–170 D 90–110 Or Both	165	47	62	155	89
Second S 171–200 D 111–120 Or Both	77	22	63	184	96
Third S 201 and over D 121 and over Or Both	15	4	62	208	110
Normal	97	27	63	137	80
Total	354	100	62½	171	94

TABLE 2.—FINDINGS CLASSIFIED ACCORDING TO AGE GROUPS

AGE GROUP	NO. OF MEN	PERCENTAGE	AVERAGE AGE	AVERAGE SYSTOLIC	AVERAGE DIASTOLIC
55–60	230	65	57¼	171	94⅓
61–65	103	29	62½	169	98⅓
66 and over	21	6	67½	173	88⅓
Total	354	100	62½	171	94

Findings

All measurements in this series were taken by the writer from the brachial artery near the bend of the elbow, with the subject in a sitting position. A Tycos sphygmomanometer, checked against a mercury manometer, was used. The maximum systolic pressure was read at the point where the first sounds, regular for the individual examined, were heard, after the cuff was blown up and the pressure gradually reduced by the needle valve in the hand bulb. The first audible click, the result of an occasional strong beat breaking through, was not considered.

When the loud, clear pistol-shot tone gave way to a muffled tone, this point was read as the diastolic sound. The diastolic pressure was not estimated at the disappearance of all sounds.

In a consideration of the findings, it should be remembered that the men were examined for the purpose of determining their condition; they did not come to seek medical advice. Only a small percentage stated that they were under medical care. Practically all felt that they were able to continue with the work which they were doing. It was found that 51 per cent. had had their activity limited because of old age; they no longer had the physical strength to do hard work. The important problem then arose as to what to do with the remaining 49 per cent. who were still engaged in heavy work.

The average age of the 354 men examined was $62\frac{1}{2}$ years (Table 1). The average systolic pressure was 171; from this it may be concluded that the systolic pressure of men over 55 years of age engaged in the steel industry is above normal. The average diastolic pressure was found to be 94; this also indicates that these workingmen had an average diastolic pressure higher than normal. Twenty-seven per cent. were classified as normal. Under first degree hypertension there were 165 men, or 47 per cent.; the average age was 62, the average systolic pressure 155, and the average diastolic 89. Under second degree hypertension there were seventy-seven men, or 22 per cent.; the average age was 63, the average systolic pressure 184, and the average disastolic 96. For third degree hypertension the average age was 62. In this group there were fifteen men, or 4 per cent.; the average systolic pressure was 208, and the average diastolic 110.

The men were also classified in three age groups: 55 to 60, 61 to 65, and 66 and over (Table 2). It was interesting to find that in all three age groups the average systolic pressure, and also the average diastolic, was essentially the same. This finding might indicate that in men over 55 years, age of itself does not necessarily predispose to hypertension.

Conclusions

On the basis of the findings reported, the following conclusions may be drawn:

1. Arterial hypertension is an important problem in industry.
2. Some definite classification is essential for a working basis.
3. Reexamination and reclassification are advisable in cases of hypertension.
4. Limitation of physical effort is advisable for men with second degree hypertension; absence of physical effort is essential for those with third degree hypertension.
5. In men over 55 years, age of itself is not indicative of the blood pressure.

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HISTOPATHOLOGY OF DIFFERENT TYPES OF ELECTRIC SHOCK ON MAMMALIAN BRAINS*

L. Raymond Morrison, M.D.
Arthur Weeks
and
Stanley Cobb, M.D.
From the Department of Neuropathology, Harvard Medical School, Boston, Mass.

LITERATURE is legion on the subject of electric shock, covering, as it does, virtually every phase of importance from the ultra-academic to the most practical aspects. From the very earliest times, in terms of the electrical era (Priestley, 1766), experimental work has been directed toward ascertaining the mode of death, the cause of death, and the best method of resuscitation.

Cunningham (1), basing his opinion on a splendid experimental study, maintains that because of ventricular fibrillations and the consequent fall of the blood pressure to zero, there is anemia of the brain which causes death. The same reasoning is followed by Crile and Macleod (2), Werner (3), and Tatum (4). Most investigators, however, seem to include the respiratory system, as well, in the mechanism of the production of death. The excellent series of articles by Prevost and Battelli (5) indicates that ventricular fibrillations can cause death in currents of low tension, but that the respiratory center is partially or totally paralyzed in high tension shocks. They found that the blood pressure fell in currents of less than 1,000 volts and rose in high voltage currents. Some such idea was in the mind of d'Arsonval (6), who believed it was the difference in potential in alternating current that caused respirations to cease. Chavany and Martin found that high tension currents caused a cessation of respiration. Urquhart (7) found that death may be caused by cardiac failure, respiratory failure, or a combination of both, depending upon the direction of flow of the current through the body. Kawamura (8) and Werner (3) state that blood is hemolyzed by some electric shocks and that this may cause death.

In order to substantiate one or the other of these views, the therapeutics of electric shock have been directed to artificial respiration, counter shock, and stimulation of the heart. It seems that men who are knocked off the poles by electric shock have more chance of recovery than those who do not fall. This has given rise to the practice of counter shock. This method of resuscitation, however, gave unsatisfactory results in a series of experiments conducted by Campbell and Hill (9), and it is not recommended by most authors. Prevost and Battelli claim that the normal rhythm of

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the fibrillating heart can be restored by a second high frequency shock ("ni trop faible ni trop forte"). The most highly recommended of all methods, however, is prone pressure (6) (7) (10).

The data collected on these points are invaluable in giving an insight into the deleterious effects of electric shock, from a more or less clinical point of view; the divergence of opinion, however, concerning both the cause of death and the best method of resuscitation is due, at least in part, to inadequate information in regard to the pathologic effect of electric current on the tissues of the body. It is only very recently that attempts have been made to obtain anything like exact evidence concerning either the nature of the current causing the shock or the actual pathology produced by such a current. Mott and Schuster (11) found in the ganglion cells of the brain of a man who lived several hours after a shock, swelling, chromatolysis, and the formation of an intracellular network. Kawamura (12) found similar changes, especially in the vagus nuclei. Spitzka and Radasch (13) found a perivascular necrosis about which more will be said later, which Jaffé (14) interpreted as having been caused by heat. Small perivascular hemorrhages have been described by Mott and Schuster, Kawamura, Werner, van Gieson, and others.

Urquhart, in 1927, made an attempt in an experimental study on animals to measure in an accurate way the current as it actually passed through the body. Most of his animals were killed outright by these shocks and as a result he found practically no pathologic changes in the tissues of the body. Then MacMahon (15), two years later, realized that it takes time for most lesions to develop so as to be visible under the microscope—a point not mentioned by Urquhart. MacMahon did not measure or interpret the kind of electric current used, for his principal interest was in the cardiac pathology, but he found quite decided changes in the central nervous system, especially the spinal cord, as well as in some other tissues of the body.

This is typical of the sort of thing one finds in the entire history of electric shock. Some of the earlier work, such as that of Cunningham and of Prevost and Battelli, which is now thirty years old, was remarkably accurate at the time it was done, but the information it contains is not exact enough in the light of more modern methods. It seemed of value, therefore, to know the exact nature of the electric wave as it passed through the body, to obtain an insight into its physiologic effect, and later to determine the pathology produced by such a wave.

Experimental Procedure

Experiments were conducted on a series of fifty-two animals—rabbits, guinea-pigs, and cats—with the purpose in view of obtaining certain information on various phases of electric injury, but most particularly to study the pathologic effect produced on the brain by repeated sublethal shocks of a given quality and quantity of current. Of the fifty-two animals, forty-four were used for histopathologic study.

The apparatus used to administer

electric shocks with several wave forms, to determine the wave shapes, and as far as practicable to measure the electrical values, was very generously furnished by the Edison Electric Illuminating Company of Boston.[1] With this equipment (a diagram of which can be seen in Fig. 1) four different types of electric waves could be administered, covering wave forms of most divergent characteristics. Since the buildings of the Harvard Medical School are supplied with 110-volt direct current circuit, a one-third horse-power rotary converter was used to produce an alternating current with a frequency of 60 cycles and of approximately sinusoidal wave shape. This, with the 110-volt direct current lighting supply, furnished two forms of current. A third was produced by a spark coil which had a vibrating reed make-and-break device in the primary, and which was fed by the 110-volt direct current system. The fourth form of current was administered by placing a condenser with a capacity of 32.2 microfarads in parallel with the animal, and periodically impressing the 110-volt direct current line across both. A contact mechanism, driven by a 6-volt motor, impressed and opened the direct current.

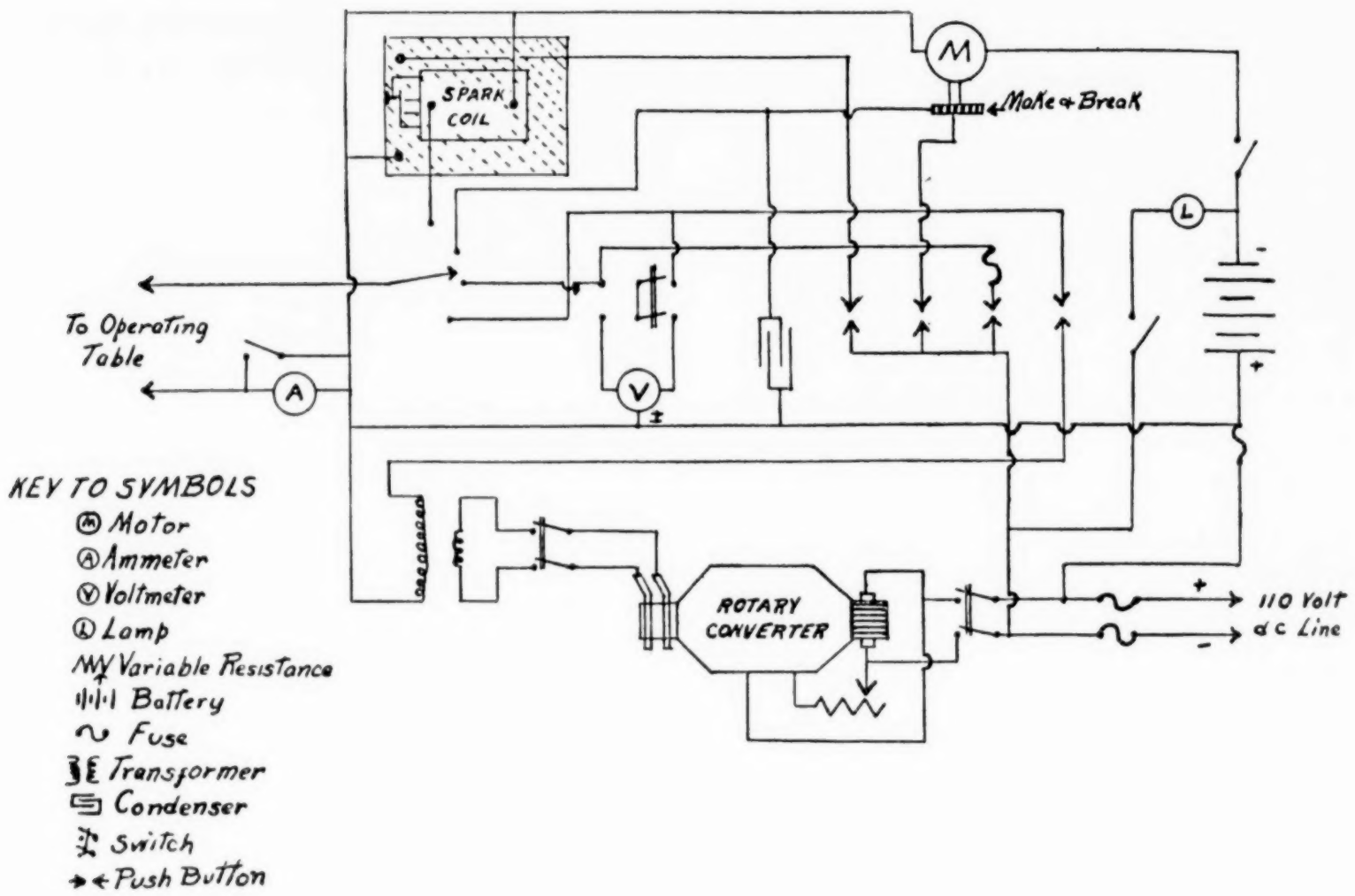

FIG. 1.—Diagram of electrical equipment.

The shock was ordinarily administered through two copper electrodes covered with saline-soaked pads and held in position by elastic bands. The head of the animal was shaved over the occiput and one electrode was applied at that point; the other electrode was in contact with the nose.

[1] Standardizing and Testing Department—C. L. Kasson, Consulting Engineer.

In all cases a light ether anesthesia was used. In a few cases (referred to separately) trephine holes were bored with a dentists' drill and electrodes inserted into the holes; in others the animals had one electrode placed on the occiput and the other on one of the hind legs.

The animals shocked by the occiput and nose contact, which represent the great majority of the series, were numbered and daily records were kept of their clinical condition, the number of shocks received, the duration of the shocks, and the electrical values (when they could be measured) such as volts, amperes, watts, and frequency. No animal, after having been shocked with one kind of current, was ever exposed to a different kind of current, except for a very particular reason, and such cases are so designated. Thus data on the selective actions of the various currents could be obtained. The number of shocks received varied in different animals, ranging from one to forty-nine in the guinea-pigs, while one cat received as many as ninety-four. The duration of life after the shocks also varied from immediate death during the shock to twenty-six days, except in two instances: a pregnant pig was permitted to live seventy-two days to deliver and bring up her young; and one cat was kept for four months.

The same histopathologic routine was followed for practically all cases. The brains were removed and blocks were cut out for fixation in formol-bromide and Weigert's glia beize; the rest of the brain was fixed in neutral formol (10 per cent.). Frozen sections were made for Hortega's methods for oligodendroglia and microglia, Cajal's gold chloride method for macroglia, Bielschowsky's method for neurofibrillae, Spielmeyer's method for myelin sheath, oil-soluble-O method for fat, Alzheimer and Alzheimer-Mann method for glia and eosinophilic degenerations. The rest of the formol-fixed part of the brain was embedded in paraffin and the sections were stained with kresylecht violett, hematoxylin and eosin, and by the van Gieson method. Other stains were occasionally done, such as Weigert-Pal, Perdrau, Mallory's connective tissue, mucicarmine, or the superimposition of a fat stain on the Hortega or Bielschowsky method.

The silver stains were not very successful on the guinea-pig material; therefore the more detailed parts of the Abbau process were studied from the brains of cats and rabbits. Controls were run on supposedly normal animals and the various series of test animals were controlled one against the other.

It is obvious that the experimental conditions are utterly artificial, but it is only by making conditions artificial that one can control them. The cerebral pathology produced by this method of chronic shocking merely serves to bring out by exaggeration the tendency of the pathologic process.

d'Arsonval instruments were used to measure the direct current, and instruments which gave root-mean-square values to measure values for the other wave shapes. An oscillograph was used to determine the wave shapes and to verify the measurements. The general characteristics of each wave shape may be seen by

reference to typical oscillograms (see Figs. 15 to 24). The following nomenclature is used throughout:

I = current
Ic = calibrating current
E = voltage
Ec = calibrating voltage
T = timing wave

The arrow points in the direction in which events take place.

The direct current was not photographed because the approximate wave shape is well known and the values can be accurately measured by d'Arsonval instruments. It produces a stress in one direction practically constant in value. Since generating machinery was used, a slight ripple was brought about by the commutator.

Induction Coil Experiments

The current from the spark coil is shown in Figures 15 and 16. Figure 15 shows the initial effect when the coil is started, and was taken with a low film speed. Figure 16, taken during a shock, shows more detail because the film speed was increased.

In Figure 15 the current rose abruptly at the instant the contacts of the vibrator closed. It was maintained at nearly the maximum value for the time the contacts remained closed, and fell sharply with a damped oscillation (shown more clearly in Fig. 16) as the contacts opened. This oscillation was caused by opening a reactive circuit. A condenser was necessary across the vibrator contacts to reduce arcing, and this soon acquired a charge from the successively impressed voltage. This charge caused a flow of current through the primary winding in a reverse direction when the contacts were open, producing a current in the secondary which gradually decreased as the condenser became discharged. Before zero was reached, the contacts again closed, causing another abrupt rise in the original direction. The timing frequency for the oscillogram in Figure 16 was 62 cycles per second; this shows that the spark coil frequency was of the order of 140 cycles per second.

In this series there were eleven animals ranging from a pig that died on the second day after a few three-second shocks, to a cat that received ninety-four fifty-second shocks in twenty-four days. These were by occiput and nose contacts. There were two cats that received intracranial shocks, one of these receiving seventy-one forty-five-second shocks in one month and being permitted to live three months more.

A typical case is seen in P. XIV S.C. in which, by occiput and nose contact, twenty-two ten-second shocks were administered in six days and the pig died on the eighth day. There are many capillary hemorrhages in the pia and throughout the brain substance, and most of the blood vessels are engorged. Nearly all the regions of the brain are involved, including the lobus olfactorius lateralis, ventriculus lateralis, corpus striatum, thalamus, corpora quadrigemina antica and postica, spots throughout the entire mesencephalon, myelencephalon, and cerebellum. In such places as the meshes of the brachium pontis, the extravasation is more marked. These hemorrhages are, as a rule, very minute; only those in the pia or the ventricles assume any sizable proportions. Most of the blood is in a fresh

condition, but occasionally it can be seen that the red blood corpuscles have lost their clear-cut characteristics, and in among them small granules of iron are present and fibrin can be detected. Sometimes within a blood vessel, white as well as red corpuscles can be seen in partial organization, as in thrombosis. This is especially likely to be found in blood vessels of the pia.

The pia itself is but slightly altered. It is thick over the basilar surface and very mildly infiltrated with lymphocytes. This infiltration does not extend to the blood vessels, and in the entire brain there is practically no perivascular reaction of blood elements.

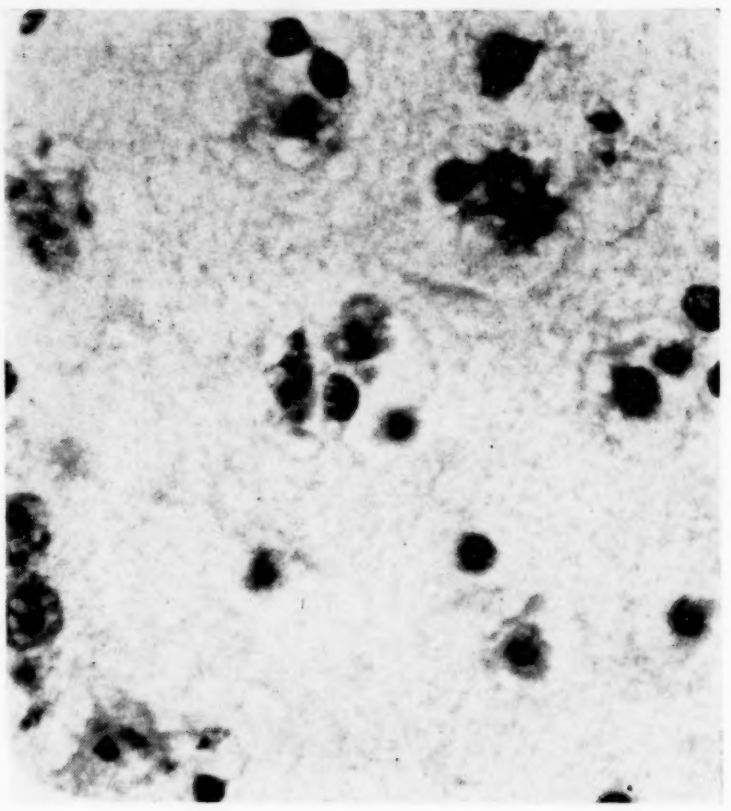

FIG. 2.—Swelling and vacuolation of ganglion cells (Nissl).

The ganglion cells exhibit extraordinarily interesting lesions of both the swollen and the shrunken types of degeneration. The first and second layers of the cortex appear rather normal in nearly all regions of the brain; it is the deeper layers, particularly the third and fourth, that show most marked pathologic changes. These changes consist principally in swelling and liquefaction of the ganglion cells, with occasional interspersed shrunken cells. All stages of swelling are visible (Fig. 2), increased convexity of cell outline, chromatolysis, vacuolation, eccentricity or extrusion of nucleus, increased satellitosis, and neuronophagia. Some of these cells are hyperstainable, but most of them are pale with a reticulum visible throughout the cytoplasm among the vacuoles. Occasional chronic swelling or axonal reaction types are to be seen, but they are by no means common.

The shrunken cells, which are quite numerous but in no way to be compared in number with the swollen cells, represent both types of shrinkage: the pale, pyknotic chromatolytic cells with elongated sharp processes of the ischemic type; and the so-called chronic type with thin hyperchromatic, pyknotic bodies, homogeneous cytoplasm, and deeply stained degenerated nuclei or absent nuclei. Some of these cells also show signs of neuronophagia.

In the basal ganglia, mesencephalon, pons, and medulla, changes similar to those already described for the cortex are everywhere to be found. While there are many cells apparently normal, a great percentage (perhaps 50 per cent.) of the cells show this acute swelling and liquefaction going on with glial involvement to neuronophagia (Fig. 3).

The reaction of the glia is not limited to active satellitosis. While there is a general increase in the number of oligodendroglia nuclei sur-

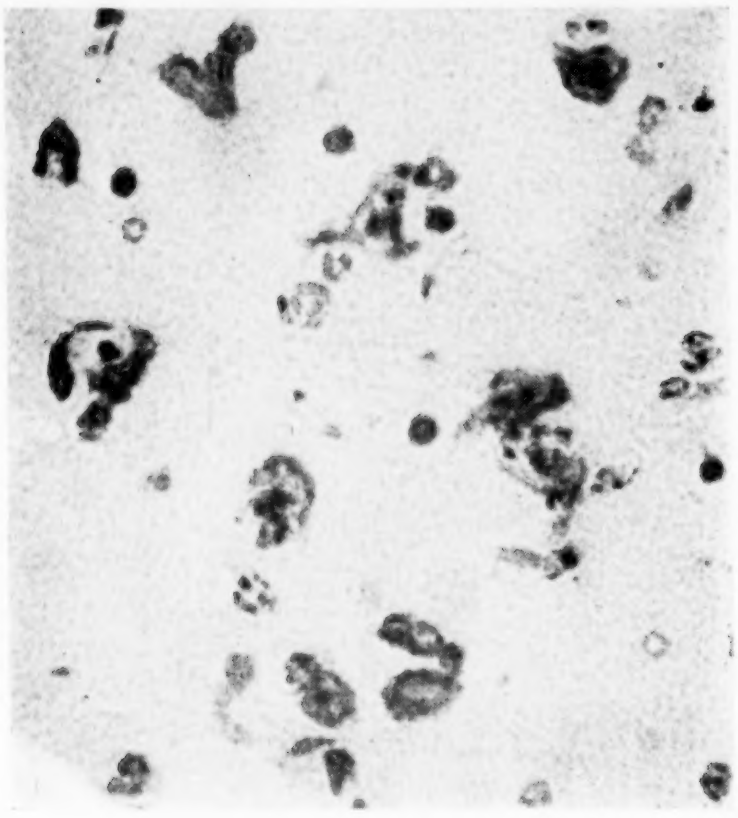

FIG. 3.—Neuronophagia (Nissl).

rounding ganglion cells in the cortex and brain stem, there are also other signs of glial activity. There is a rather pronounced subependymal gliosis consisting very largely of macroglia with some microglia participating (Fig. 4). This same increase in glia is occasionally seen around blood vessels.

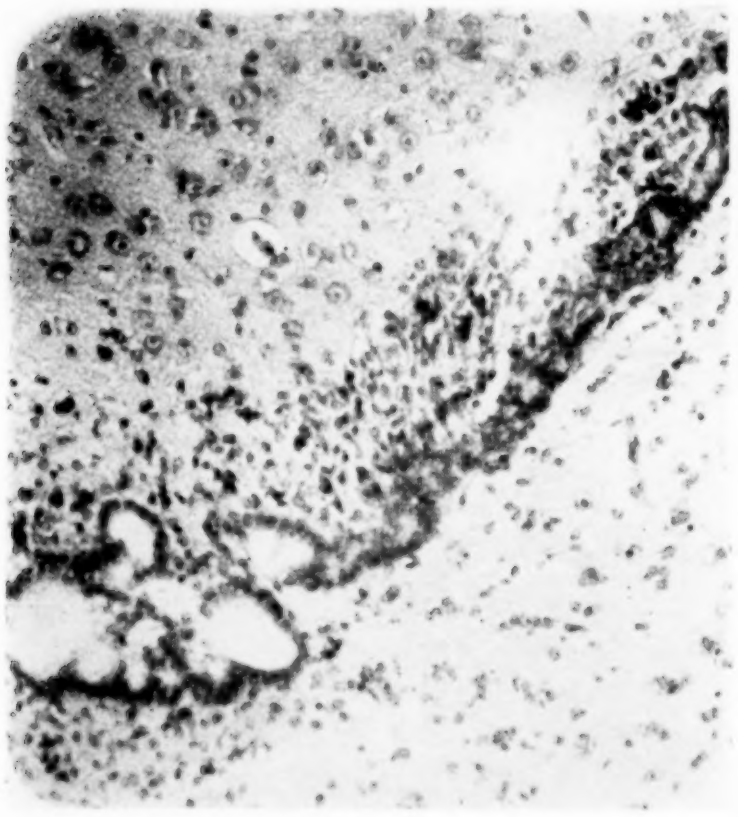

FIG. 4.—Subependymal gliosis (Nissl).

Hyperstainability of the glia is seen in the Nissl picture, when the perikaryons as well as some of the prolongations become visible around the nuclei of astrocytes and microglia. Quite frequently little clumps of three or four glial nuclei designate the site of a former ganglion cell.

In the Spielmeyer preparations an involvement of the myelin can be demonstrated. No particular regions or systems seem to be predisposed to this myelin breakdown, but rather it is generalized and areas that carry many fibers, such as the corona radiata, capsula interna and tractus opticus, exhibit swollen sheaths, myelin balls, and open plaque-like spots of demyelinization. If there is a predilection for any part, the corona radiata is most affected. (Fig. 5.)

FIG. 5.—Demyelinization (Spielmeyer).

The neurofibrillae are not greatly involved, but in the thalamus most particularly one sees swollen and tortuous axons (Fig. 6). In the

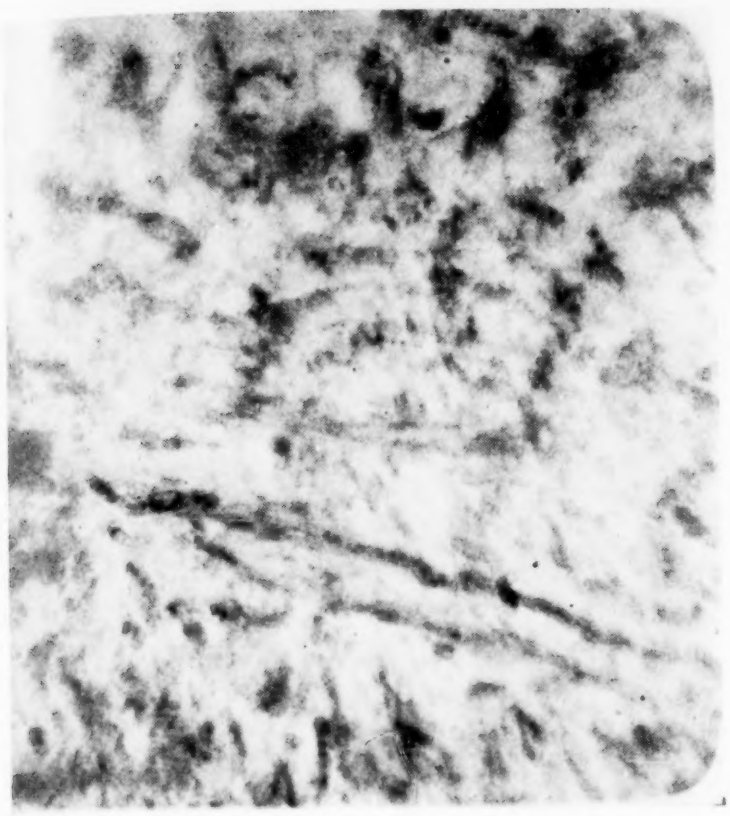

FIG. 6.—Swollen neurofibrillae (Bielschowsky).

FIG. 7.—Gitter cells (oil-red-O).

capsula interna, also, excessively wavy, swollen, beady and fragmented axons can be discovered, and while this is not a striking phenomenon it is not uncommon.

Very little fat can be found in this case, but it is not entirely absent. Around many of the smaller blood vessels in the white matter of the cortex as well as the thalamus and medulla, fine fat droplets can be detected. Some of the ganglion cells show fat as well, and very often a glial nucleus is found surrounded by a fat-laden cytoplasm in the form of a typical gitter cell (Fig. 7).

In the myelinated areas, besides fatty degeneration there is another, and a very striking, form of degeneration. The white matter in nearly all parts of the brain is vacuolated in a most unusual manner. These vacuoles are roughly spherical. Sometimes they have clear-cut edges but frequently they are irregular and lobulated, and in cross sections they resemble in arrangement the petals of a flower. Very often on one side of the rim of such a hole the nucleus of an oligodendroglia is found, and in some cases within the hole is one or more of these nuclei. In ordinary hematoxylin and eosin, paraffin-embedded sections, a thin citrous-colored filmy substance can, by careful focusing, be made out within these vacuolated spots (Fig. 8). In van Gieson, hematoxylin and eosin, kresyl-

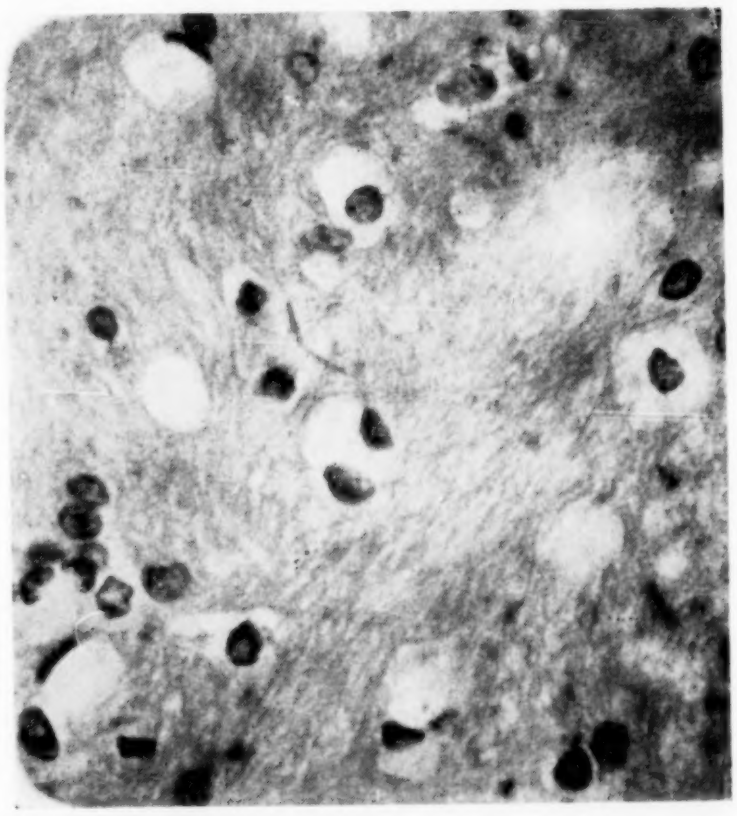

FIG. 8.—Pseudomucoid degeneration (hematoxylin and eosin).

echt violett, and Mallory's connective tissue stains, these areas are visible, but in frozen sections they cannot be seen. A few special stains—methylene blue, Giemsa, Sheldon-Dyar, Alzheimer-Mann, etc.—done to detect if possible the nature of the substance within the holes, show that it is basophilic and practically homogeneous. The mucicarmine stains it pink.

Alzheimer-Mann stain brings out a very pretty feature of the Purkinje cells, showing that they are usually shrunken (but occasionally swollen) and that some of them are entirely red, while others merely have red nuclei or nucleoli. In some folia of the cerebellum entire rows of the Purkinje cells are thus eosinophilic.

While this case exhibits typical lesions for the induction coil current, all the animals did not present exactly this degree of pathology. Some showed milder changes and others changes of greater intensity, but in all cases where induction coil shocks were used, the same features were dominant: hemorrhage, demyelinization, glial proliferation, and excessive swelling and liquefaction of the ganglion cells.

Swelling of the oligodendroglia is probably one of the first signs of pathology; it occurs in cases of short shocks of three seconds in which death occurred within a few hours, and also in cases of longer shocks of thirty to fifty seconds in which death followed at once. In these cases there is one other lesion, pericapillary hemorrhage, which is the other very early sign.

In the old cases that have lived for weeks after severe shocks, lesions that are to all intents and purposes chronic

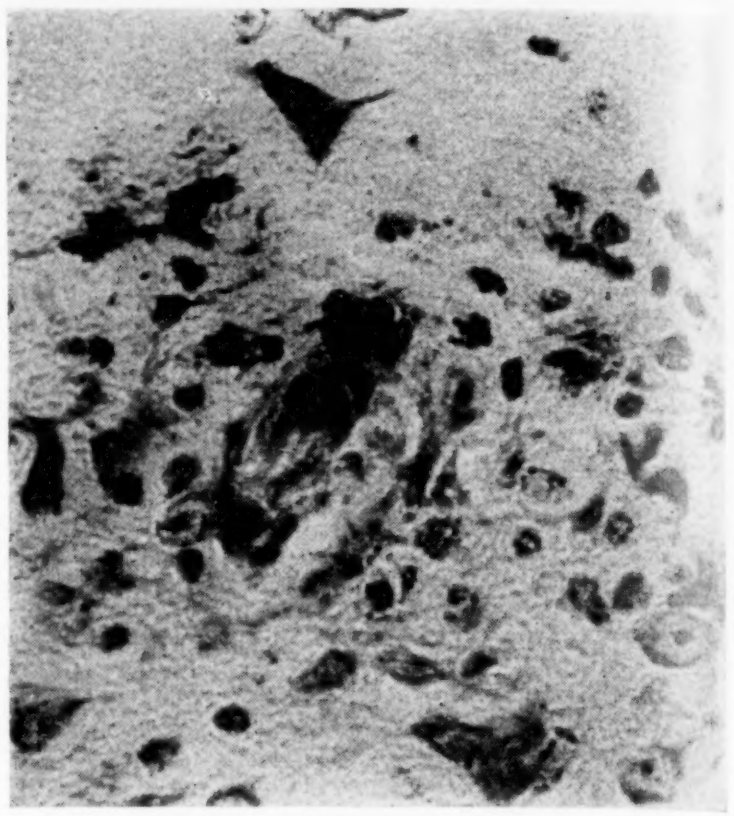

FIG. 9.—Perivascular gliosis.

are seen. Perivascular gliosis (Fig. 9) and demyelinated spots (Fig. 5) are lesions of this type.

CONDENSER DISCHARGE EXPERIMENTS

The oscillograms in Figures 19 and 20 are typical of the current when the condenser was used across the animal; Figure 19 shows the initial effect as the current was switched on, and Figure 20, the current during the shock in more detail, since the film speed was increased. Consideration of Figure 19 shows that the current rose sharply when the contact with the direct line was made, and continued to rise at a slower rate while the contacts remained closed, for the first few charges. When the contact with the power line was broken, the current decreased as the condenser discharged through the animal. Zero was not reached before the line contact was again made, causing another abrupt rise. The condenser gained a little charge at each successive connection with the line until it reached a

stable condition, after which the current did not rise further while the contact was made. The short high value of current observed at the instant of make seems to be a damped oscillation set up by the reactance of the circuit. Reference to the timing wave, which was 59 cycles, shows that contact with the line was made about fifty-five times a second.

Not only is the wave form of the condenser discharge similar to the induction coil wave, but also the lesions produced by both types of current are practically identical. All degrees of intensity are to be found, depending upon the number and durations of the shocks and the length of life of the animal. In this series there were eleven animals—guinea-pigs and cats—which were shocked various numbers of times from twelve to forty-nine, and which lived after the shocks from seven to seventy-two days.

As in the induction coil series, the blood vessels in the pia and throughout the brain substance are engorged and small capillary hemorrhages are found in all regions. Some of the older hemorrhages exhibit partial organization. The ganglion cells present the same liquefaction and swelling although some of them are definitely shrunken, exhibiting both ischemic and so-called chronic shrinkage types. Variation in degree of degeneration, depending upon the intensity of the shock, can be followed from the earliest signs of swelling to complete neuronophagia. Glia are increased in number, size, and activity in the myelin and around cells, blood vessels, and ependyma. In several cases regressive changes of the ependyma are seen in which the cells become greatly

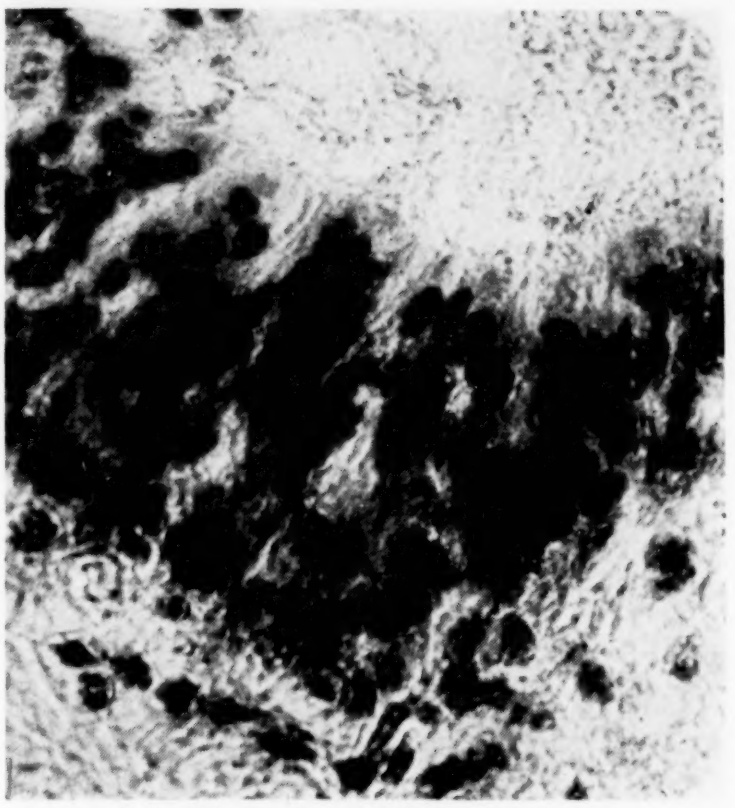

FIG. 10.—Regressive changes of ependyma (Nissl).

elongated and fusiform, and present a thick irregular layer as in gas poisoning (16) (Fig. 10). Beneath such a layer the microglia and macroglia are usually dense. The choroid plexus, as well as the ependyma, shows changes; in the ventriculus lateralis in one case and in the ventriculus quartus in another, a distinct choroiditis is present (Fig. 11) in which lymphocytes infiltrate.

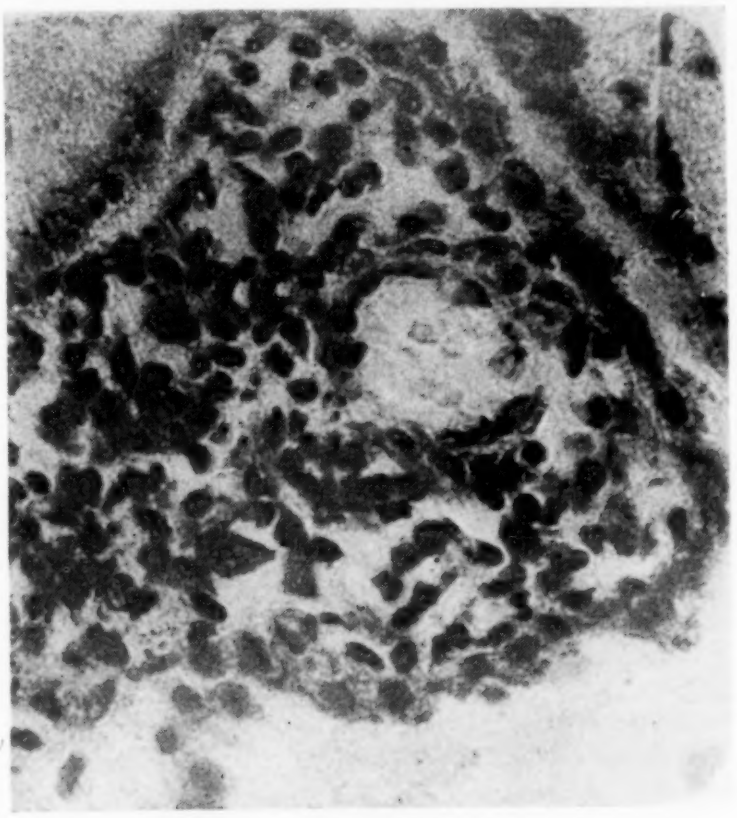

FIG. 11.—Choroiditis (Nissl).

There is some breakdown of the myelin with the production of swollen myelin sheaths, myelin balls, and plaques of demyelinization; in the older cases the axis cylinders are missing in these demyelinated areas although in earlier cases the neurofibrillae seem unaltered. The fat has been just as elusive in this as in the previous series, and can only be detected with difficulty even in the cases that show marked demyelinization. When it is seen, it appears in all the conventional places in ganglion cells, in glia of the white matter, and around blood vessels. The vacuoles with their filmy coagulum are everywhere visible, even in very early cases, and the white matter especially is filled with them. Eosinophilia of the ganglion cells, notably in early cases and particularly in the thalamus, as well as of the Purkinje cells, is to be found.

One lesion not seen in the induction coil series but present in four of the animals of this series is a sort of perivascular necrosis (Fig. 12) apparently similar to that reported by Spitzka and Radasch, in which a blood vessel usually containing organized blood is situated at the center of a rarefied, web-like mass, rather more dense at the periphery where it butts against comparatively normal tissues. In general, however, the pathologic picture is the same as that seen in animals shocked with the induction coil.

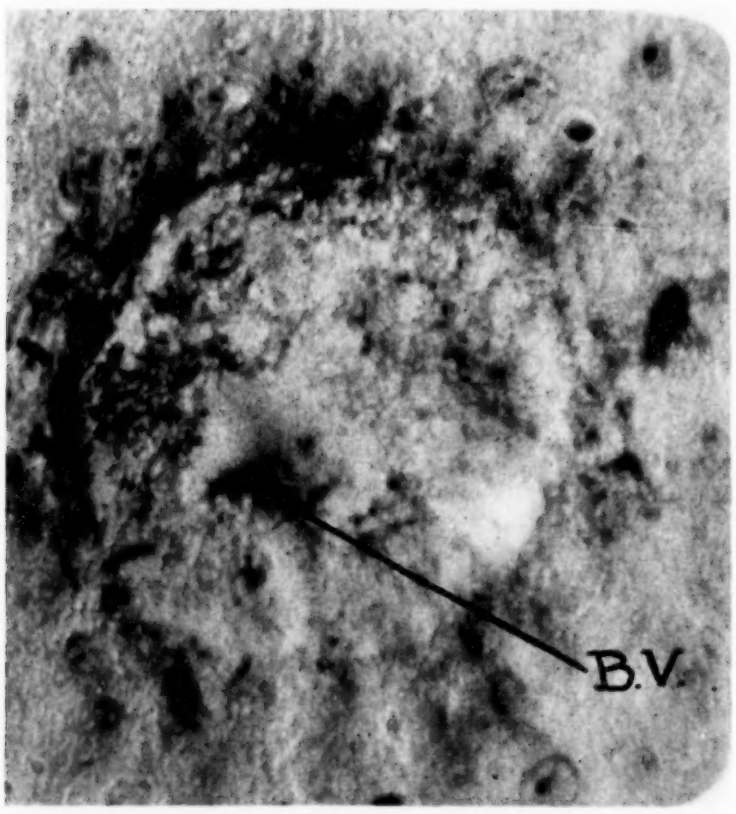

FIG. 12.—Perivascular necrobiosis (Nissl).

ALTERNATING CURRENT EXPERIMENTS

The alternating current (see Fig. 22) was sinusoidal in wave shape and had rather marked tooth harmonics common to small machines such as the rotary converter used.

The animals in the alternating current series, consisting of fifteen pigs, two cats, and a rabbit, were shocked by the same method of occiput and nose contact. The length of life varied from twelve hours as in the case of the first pig, which received one five-second, 12-volt, 10-milliampere shock, to nineteen days as in the case of the last pig, which was shocked with 180 volts, 490 milliamperes, for five seconds on sixteen different occasions. The lesions produced by this type of current are in several respects different from those produced by the induction coil current and by the condenser discharge.

In the first place there is a greater tendency to hemorrhage in the alternating current series. The hemorrhages in the pia, particularly over the superior convexity and in the fissura rhinica, as well as in the ventricles and in the choroid plexus, are more extensive. Often the hemorrhage is organized, especially in the

pia, but in early cases whole blood is present. The pericapillary extravasations are much more frequent, especially in the basal ganglia and the medulla. All the blood vessels are engorged with blood and in some places, notably in Ammon's horn, the perivascular spaces are greatly distended, sometimes with blood but more frequently without any substance visible in them. A mild proliferation of the intima with a few lymphocytes in the vessel wall is occasionally seen, and most often in the medulla.

There is some reaction around blood vessels. It is mild and is visible only in the older cases and is not altogether clear, but there are a few vessels in several of the cases, most frequently in the medulla oblongata and in the white matter of the cortex, around which a few lymphocytes and the nuclei of other cells (which in cats proved to be oligodendroglia) are visible. The pia, also, in a few cases shows a light infiltration of lymphocytes (Fig. 13).

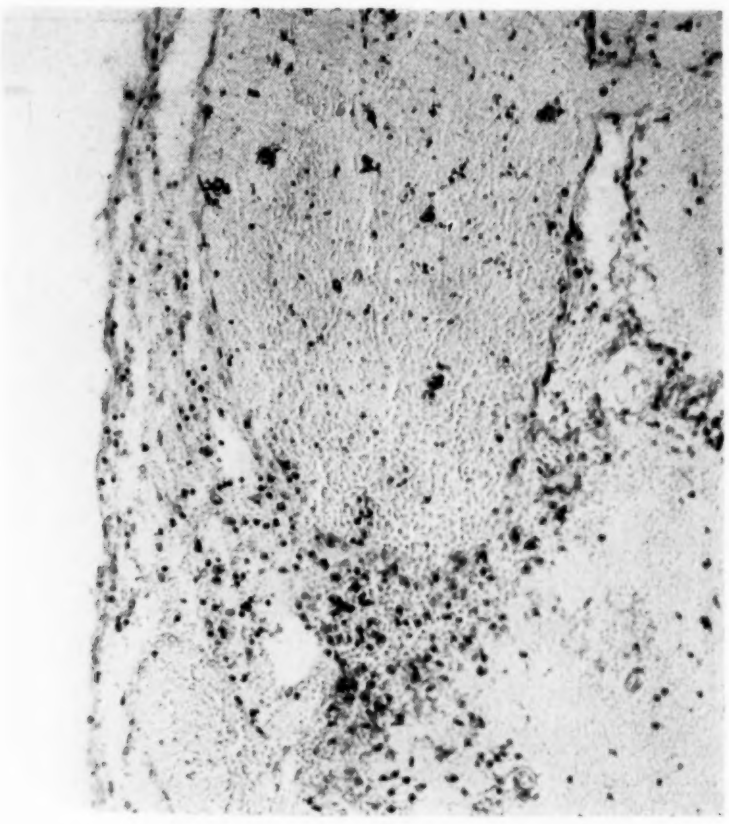

FIG. 13.—Hemorrhage in pia with slight infiltration (hematoxylin and eosin).

The acute liquefaction of ganglion cells, so commonly found in static and induction coil currents, is relatively absent in these cases. There are occasional swollen cells to be seen in the thalamus, and in the brain stem, but the conspicuous type of cell disease is shrinkage. Both types are found and it is difficult to say which type predominates; in some animals the chronic shrinkage type is more plentiful, while in others the ischemic shrinkage is more noticeable (Fig. 14). In any given animal it is with

FIG. 14.—Ischemic shrinkage of ganglion cells (Nissl).

hesitation that one says that the outer cortical layers show more of the chronic type, while the deeper cortical layers and the subcortical structures exhibit more cells that are pyknotic, lightly stained, with hyperchromatic eccentric nuclei and chromatolytic and sometimes vacuolar cytoplasm. But this tendency seems to be present. The fissura rhinica is another place that has

around it many ischemic cells. Very few cells of the axonal reaction type of swelling are to be seen. Occasionally there are interruptions in the cyto-architecture and holes are visible, where ganglion cells used to be, as in the lamina granularis externa of the area shown in Figure 14 (see atlas of Winkler and Potter (17)). These holes resemble the "areas of devastation" of Gildea and Cobb (18).

The glia in animals shocked by sinusoidal current is apparently not stimulated to such activity as in animals shocked by other wave forms. The number of glia is not noticeably increased and pathologic satellitosis and neuronophagia are not met with frequently for the reason that it is swollen cells, which in these cases are rare, rather than the shrunken cells that seem to undergo most neuronophagia. The reaction under the ependyma is, in all cases, very mild and in some cases entirely absent.

The Spielmeyer preparations show in only one case that the myelin has been affected. This animal received nineteen five-second shocks in eleven days. Each shock was of the order of 160 volts and 500 milliamperes. Several other animals that received shocks of similar severity did not show this myelin lesion.

Bielschowsky preparations show in some cases swelling of the axons, especially in the capsula interna and the corpus callosum.

The mucin-like bodies common in slides of condenser and induction coil experiments are generally absent from these sections. There is, to be sure, a considerable amount of edema but the circular spots and large vacuoles are not a feature. In the corona radiata, in some cases, there are small holes like shrinkage spaces around oligodendroglia nuclei, but they are much smaller than those described under induction coil current and they seem to have no coagulum. In these cases edema is probably the cause of such spaces.

Fat can be detected in fine droplets in certain of the degenerated ganglion cells, around some glial nuclei, and around some blood vessels. Generally, however, it is very scarce and as in the previous cases it does not seem to be present in amounts that are consistent with the severity of the pathology.

Eosinophilic degeneration, particularly of the Purkinje cells but also to some extent of some of the ganglion cells of the cortex and the thalamus (nucleus reuniens in two cases), is seen as in the animals shocked by the other types of current.

The typical pathology for alternating current thus appears, in brief, to be a greater tendency toward hemorrhage, shrinkage of the ganglion cells, very mild reaction of the glia, and an absence of demyelinization.

Direct Current Experiments

As was stated above, no oscillograms were taken to illustrate this type of current since its approximate wave form is fairly well known.

There were four animals in this series. One of them received one shock of twenty-seconds' duration and of 580 milliamperes with a pressure of 110 volts, after which it lived eight days. Another was shocked similarly thirteen times and lived thirty-four days. The remaining

two lay between these extremes. In all these cases the anode was in contact with the nose and the cathode with the occiput.

Microscopically there is hemorrhage in the pia, around the small blood vessels of the cortex and the basal ganglia, and in the choroid plexus, but it is not very severe. The most conspicuous lesion is the vacuolar condition of the white matter. The corpus callosum, the capsula interna, and the pes pedunculi are most affected. The vacuoles are round and some of them contain the same sort of basophilic coagulum that was described in other types of current. This degeneration is so extensive in these cases that the white matter is virtually riddled with punctate holes. An extraordinary thing about it is that in the animal that received but one shock and then lived eight days, the holes are still present with their glial nuclei and no tendency toward reversion to the normal state is to be noted.

The outstanding lesion of the ganglion cells, and this applies to all layers of the cortex as well as to the basal ganglia, is swelling, vacuolization, and liquefaction necrosis, in which chromatolysis, extrusion of nucleus and, to some extent, neuronophagia participate. Neuronophagia is not so common as one would expect, however, and in the case of the single-shock pig in which eight days elapsed for the glial reaction, it is noteworthy that many little glial proliferations actually occurred. Not only are neuronophagia and pathologic satellitosis not features, but also the absence of subependymal gliosis is a point of difference between these and the spark coil cases.

There is no noticeable myelin breakdown, in the ordinary meaning of the expression, but the vacuolar lesions that are everywhere conspicuous in the medullary portions of the brain indicate a severe interruption of myeloarchitectonics. The medullary sheaths are, however, but slightly swollen and there is practically no fat to be found.

In the older cases, which have received more shocks, the hemorrhage is much more severe, and depending upon the duration of life shows more organization and more iron deposit. Then, too, a peculiar condition of the nuclei of the ganglion cells is observable. In spite of the fact that chromatolysis occurs in the cytoplasm, the nucleus is hyperstainable and around its periphery the chromatin is arranged as a stippled ring. In the animal that received most shocks there is an increase in perivascular and pericellular glia.

Two of the animals were killed by placing the electrodes on the occiput and the hind leg, and they both exhibited hemolyzed red blood cells in the vessel apertures.

In general, then, with direct current the ganglion cells are swollen, as in the induction coil series, but the glial reaction is not so severe as in that type of case. The myelin is not broken down but the myeloarchitecture is severely interrupted by the vacuolar lesions of mucoid degeneration which are more severe in these cases than in any of the others.

(To be concluded)

THE INCIDENCE OF ILLNESS AMONG WAGE EARNING ADULTS*

DEAN K. BRUNDAGE

OUR knowledge of the health status of industrial workers in general and of certain occupations in particular up to a decade or so ago was based largely on the information afforded by mortality statistics. Such information, however, has always been very scanty in this country, because we do not have national mortality statistics according to occupation such as those published decennially by the Registrar-General of England and Wales. For only two years, 1908 and 1909, has the Federal Census Bureau published the number of deaths according to occupation. Some of the larger insurance companies in the United States have made available from time to time proportionate statistics by occupations, but *rates* according to occupation had not been available from any considerable experience until the publication recently of the Joint Occupation Study by the Actuarial Society and the Association of the Life Insurance Medical Directors.

Progress in the development of plans for occupational mortality statistics for the country as a whole has been slow, not only on account of the technical difficulties involved, but also because of the realization of the limitations of such statistics; for death statistics obviously afford no information concerning the sickness that does not terminate fatally. Certain conditions of work or other causes may predispose to numerous illnesses or chronic ill health which may not terminate in death for many years. In the realization that information concerning the health of workers in industry was urgently needed, a group of vital statisticians and industrial hygienists attempted some ten years or more ago to obtain records of *sickness* among industrial workers which would afford knowledge of the amount and nature of disabling illness in sample groups of the industrial population, and especially in groups exposed to specific health hazards, such as those in certain dusty trades.

It is the purpose of the present report to review some of the industrial morbidity data that have been collected and analyzed in recent years, and to present the results that appear to be the most interesting and illuminating.

The morbidity statistics given in this paper are based on records of absences from work on account of disability among persons on the payroll of industrial establishments or belonging to industrial sick benefit associations. Causes of absence from

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work were ascertained by visiting nurses or others who called at the homes of absent employees, while the records of mutual benefit associations were of claims for sickness benefits, usually of illnesses causing absence for more than one week, which were accepted and paid after investigation by administrators of the sick benefit funds.

It is apparent at once that in dealing with morbidity statistics based on such records, one must state clearly what is meant by a "case" of sickness. In mortality statistics the unit is a "death" which is clear to all and seldom errs as to the fact; but in sickness a case may vary all the way from a subclinical indisposition to an extremely serious pathologic condition. The most feasible method of defining a case of illness appears to be in terms of a "waiting period"; that is, an absence on account of disability is included in the record if it lasts longer than a certain minimum duration, such as one day, two days, three days, a week, etc. In most instances comparisons of sickness statistics are invalid if identical waiting periods are not used. Even the age curve of illness is different for disabilities lasting less than one week than for those lasting eight days or longer, as may be seen in Figure 7, in the section on "Industrial Selec-

TABLE 1.—FREQUENCY OF ABSENCE DUE TO DISABILITY, ACCORDING TO DURATION IN WORKING DAYS (1922 TO 1924), AMONG EMPLOYEES OF A COMPANY WHICH PAYS WAGES DURING DISABILITY AS COMPARED WITH EMPLOYEES OF A COMPANY WHICH DOES NOT

(Both companies in metropolitan area of Boston)

DURATION OF ABSENCE IN WORKDAYS	MALES		FEMALES	
	Company Which Pays	Company Which Does Not Pay	Company Which Pays	Company Which Does Not Pay
All durations	1,198	383	2,408	710
1 day	418	...[1]	1,235	...[1]
2 days	239	57	443	115
3 days	142	55	198	104
4 days	91	40	99	72
5 days	56	35	90	59
6 days	54	33	82	69
7 days	30	18	28	29
8 days	17	12	27	22
9 days	13	12	25	23
10 days	14	8	15	14
11 days	12	10	12	17
12 days or more	112	103	154	186
No. of years of life under observation	6,129	12,148	1,508	5,374

[1] Unknown.

tion." Similarly, comparisons of the amount of time lost from work on account of disability should include only those data that are based on the same maximum period for which cases are carried in the record.

A point almost as important as the unit of measurement in comparisons of industrial sickness statistics is the provision or lack of provision for sick leave. If wages are lost entirely when the worker is absent on account of sickness, the record usually shows a much lower rate of absence for illnesses of relatively short duration than when full wages are paid during sickness. In Table 1 and Figure 1 a comparison

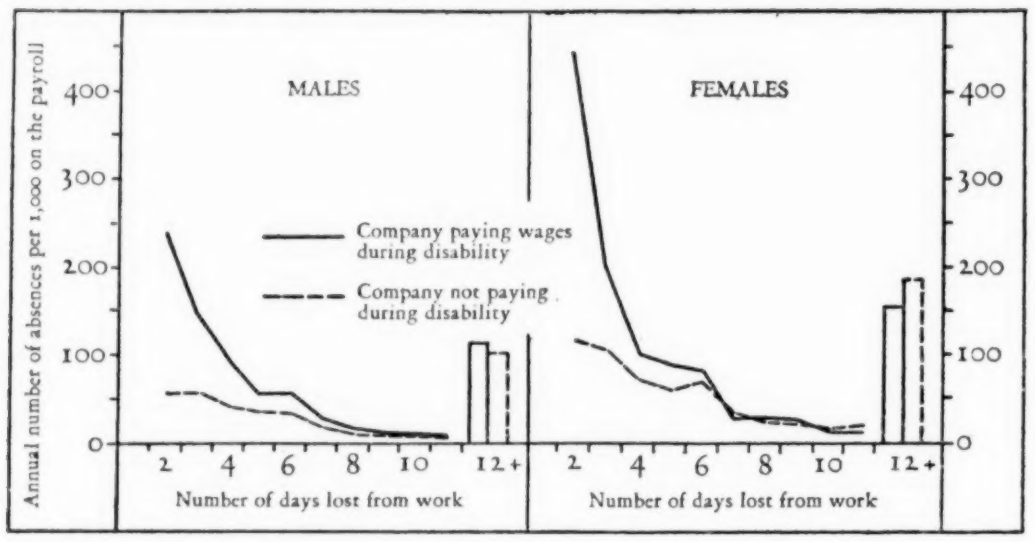

FIG. 1.—Frequency of absence due to disability among employees of a company which pays wages during disability as compared with employees of a company not paying during disability. The comparison is made for disabilities of varying durations, and for males and females.

is given of the frequency of absence of different durations due to sickness among employees of a company paying full wages and among employees of a company paying no wages during illness, both companies being located in the same metropolitan area of a New England city. In the company which paid full wages when the employee was sick, a check on malingering was maintained through a full time physician who called at the homes of employees reporting themselves as unable to work on account of illness. During a three-year period the company physician diagnosed 81 per cent. of the disabilities which lasted two days or more, and 58 per cent. of the disabilities which lasted one day only. He found that malingering was a negligible factor in the apparently high rate of sickness among employees of his company. What really happened was that the employees tended to stay home and take care of their ailments, especially their colds and other so-called minor respiratory diseases, which they could not afford to do if they lost their wages at such times. However advantageous it may appear to employers to pay workers on the basis of time spent at the factory or for goods actually produced, or for sick benefit associations to make no payment for the first week of disability, the fact remains that the spreading of disease, and especially of respiratory

diseases, which, as will be shown later, entail heavy time losses in industry, is facilitated by the tendency of the worker to stick to his job and maintain his contacts with others while sick or half sick with communicable disease. Lack of provision for sick leave as well as the failure to pay benefits for the shorter cases falls heavily upon the employee, and obviously militates against improvement in the public health.

Morbidity and Mortality Compared

As Sydenstricker has shown (1, p. 287), a striking contrast occurs in the picture afforded by sickness as compared with death records. The diseases that cause illness most frequently are respiratory (chiefly colds, influenza, bronchitis, and tonsillitis) and digestive disorders. The principal diseases which cause death are those which result in the breakdown of the circulatory system, the kidneys, the lungs, and the nervous system, and the malignant "general diseases" such as cancer. In a general population group, Sydenstricker found that the ratio of respiratory illnesses to deaths from respiratory causes was more than 300 to one, and the ratio of diseases and disorders of the digestive system showed a ratio of about 200 cases to one death. On the other hand, the ratio of illnesses of the circulatory system, kidneys and annexa was only about ten cases to one death. The record of illnesses in this study was obtained through house-to-house canvasses by field agents at intervals of six to eight weeks, and, when checked with records of *absence* on account of sickness, appeared to represent disabilities lasting longer than two days. A comparison of the causes of morbidity and of mortality emphasizes the significance of the observation with which this report was introduced. A true picture of the ill health of the population appears to be inadequately obtained by means of death statistics.

Diseases Causing Morbidity among Industrial Workers

Since 1920 a record of the frequency of different diseases has been obtained from a group of thirty-five to forty industrial sick benefit associations having a combined membership of 100,000 to 150,000 persons. These associations have reported periodically to the United States Public Health Service the cases of illness and non-industrial accidents which disabled their members for more than one week. Sickness rates based on these data have been published so frequently in the Public Health Reports that only a brief résumé of the results seems necessary.

During the eight years from 1921 to 1928, inclusive, respiratory diseases caused 42.4 per cent. of total disabilities from sickness and non-industrial accidents.[1] The second most important disease group from the standpoint of sickness frequency was composed of diseases of the digestive system. Nonindustrial accidents constituted the third most

[1] Within the respiratory group of diseases, influenza was shown to be by far the worst offender. The second most frequent respiratory disease was tonsillitis, but its incidence was only about one-third that of influenza or grip. Bronchitis ranked third in frequency, and pneumonia (all forms), fourth (2).

TABLE 2.—FREQUENCY OF DISABILITY LASTING MORE THAN ONE WEEK DUE TO SPECIFIED DISEASE GROUPS IN A GROUP OF MALE INDUSTRIAL WORKERS EMPLOYED IN DIFFERENT INDUSTRIES, 1921 TO 1928, INCLUSIVE

DISEASE GROUP[1]	ANNUAL NO. OF CASES PER 1,000 MEN	PERCENTAGE OF TOTAL CASES	NO. OF CASES
Sickness and nonindustrial injuries[2]	103.5	100.0	93,064
Nonindustrial injuries (165–203)	10.2	9.9	9,202
Diseases of the respiratory system (11, 31, 97–107, 109)	43.9	42.4	39,484
Diseases of the digestive system (108, 110–127)	14.0	13.5	12,591
Diseases of the circulatory and genito-urinary systems (87–96, 128–136)	7.1	6.8	6,347
Rheumatism (acute and chronic) (51, 52)	6.0	5.8	5,359
Diseases of the nervous system (70–84)	4.5	4.3	4,026
Diseases of the skin (151–154)	3.9	3.8	3,524
Diseases of the organs of locomotion (158)	3.4	3.3	3,071
Epidemic and endemic diseases (1–10, 12–25)	2.7	2.6	2,435
All other diseases	7.8	7.6	7,025

No. of years of life under observation: 899,064.

[1] In this and subsequent tables the numbers in parenthesis are the corresponding title numbers taken from the International List of the Causes of Death, third revision, Paris, 1920.

[2] Industrial accidents and the venereal diseases are not reported.

numerous group of causes, and diseases of the circulatory and genito-urinary systems, the fourth. The contagious and infectious diseases (typhoid fever, smallpox, diphtheria, scarlet fever, measles, mumps, etc.), upon which public health effort is often so largely concentrated, produced less than 3 per cent. of the cases for which sick benefits were paid to members of these relief associations. (See Table 2 and Fig. 2.)

The relative frequency of the broad disease groups appears not to differ radically from these percentages when the record covers all disabilities lasting one day or longer instead of cases causing absence for more than one week. The Edison Electric Illumi-

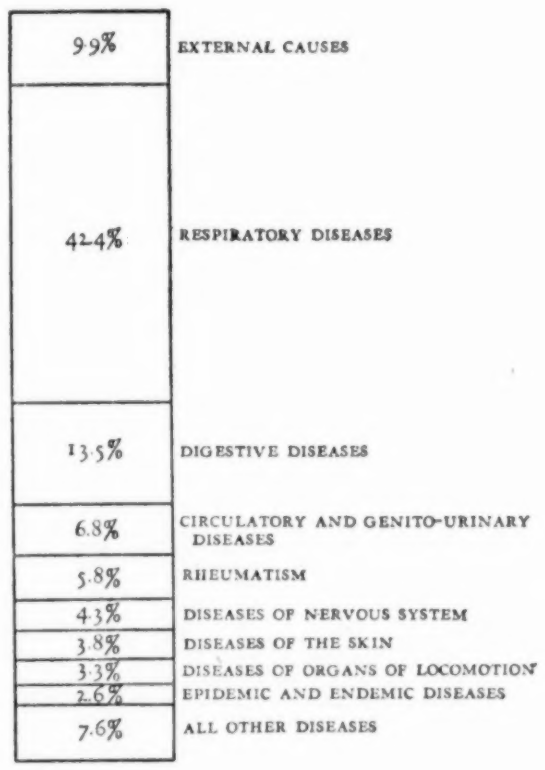

FIG. 2.—Relative frequency of claims for sick benefits on account of external causes and various groups of diseases among male industrial employees, 1921 to 1928.

nating Company of Boston found, for example, that respiratory diseases (including influenza, tuberculosis, and diseases of the pharynx and tonsils) caused approximately one-half of all the one-day and longer absences on account of sickness among its workers. The number of days of disability on account of respiratory diseases was found to average over a ten-year period, 3.2 days per year per male, and 5.5 days per year per female on the payroll of this company. Colds alone involved time losses equivalent to 1.4 days per year for every man on the payroll, and 2.1 days per year per female employee (3).

Seasonal Variation in Sickness Incidence

The sick benefit association data covering cases of more than a week's duration show little seasonal variation in the incidence of the nonrespiratory diseases as a group. Computation of the average incidence rate for each month, based on the experience of 1921 to 1926, inclusive, revealed that nonrespiratory diseases as a whole tended to be least prevalent in the late fall (October and November), and most frequent in midwinter (January and February). In contrast to the small seasonal variation shown

TABLE 3.—AVERAGE MONTHLY FREQUENCY (1921 TO 1926, INCLUSIVE) OF SPECIFIED RESPIRATORY DISEASES CAUSING DISABILITY FOR MORE THAN ONE WEEK IN A GROUP OF ABOUT 100,000 WAGE EARNERS IN DIFFERENT INDUSTRIES[1]

MONTH IN WHICH DISABILITY BEGAN	ANNUAL NO. OF CASES PER 1,000 PERSONS							
	Sickness and Non-industrial Accidents	Nonrespiratory Diseases[2]	Respiratory Diseases					
			Total	Influenza and Grip	Diseases of Pharynx and Tonsils	Bronchitis (Acute and Chronic)	Pneumonia (All Forms)	Other Respiratory Diseases[3]
July	76.8	58.4	18.4	3.7	5.2	3.0	1.0	5.5
August	83.7	62.3	21.4	5.0	5.1	3.9	1.0	6.4
September	83.1	58.6	24.5	6.8	4.8	4.5	1.6	6.8
October	86.5	53.9	32.6	12.0	6.2	5.6	2.2	6.6
November	94.5	54.8	39.7	15.4	7.4	6.3	3.1	7.5
December	106.0	56.4	49.6	21.5	8.1	7.8	4.0	8.2
January	141.6	68.9	72.7	36.3	10.7	9.3	5.0	11.4
February	168.1	67.4	100.7	61.5	11.0	10.9	5.8	11.5
March	150.9	62.9	88.0	55.7	9.0	8.6	5.6	9.1
April	117.0	64.3	52.7	26.5	8.7	5.7	4.0	7.8
May	92.1	61.2	30.9	10.8	7.3	3.9	2.5	6.4
June	80.6	59.6	21.0	4.5	6.3	3.5	1.7	5.0

[1] About 10 per cent. of the total number of persons included in this table were women.
[2] Nonindustrial accidents included.
[3] Title numbers 31, 97, 98, 102–107 in the International List of the Causes of Death.

for the nonrespiratory group, the frequency of diseases of the respiratory system tends to vary markedly with the season, reaching lowest incidence, ordinarily, in July, and peak rate of occurrence in February. The respiratory diseases which exhibited the most abrupt seasonal rise and fall were influenza and pneumonia. For bronchitis, and for diseases of the pharynx and tonsils, the seasonal curve was flatter, as is shown in Table 3 and Figure 3.

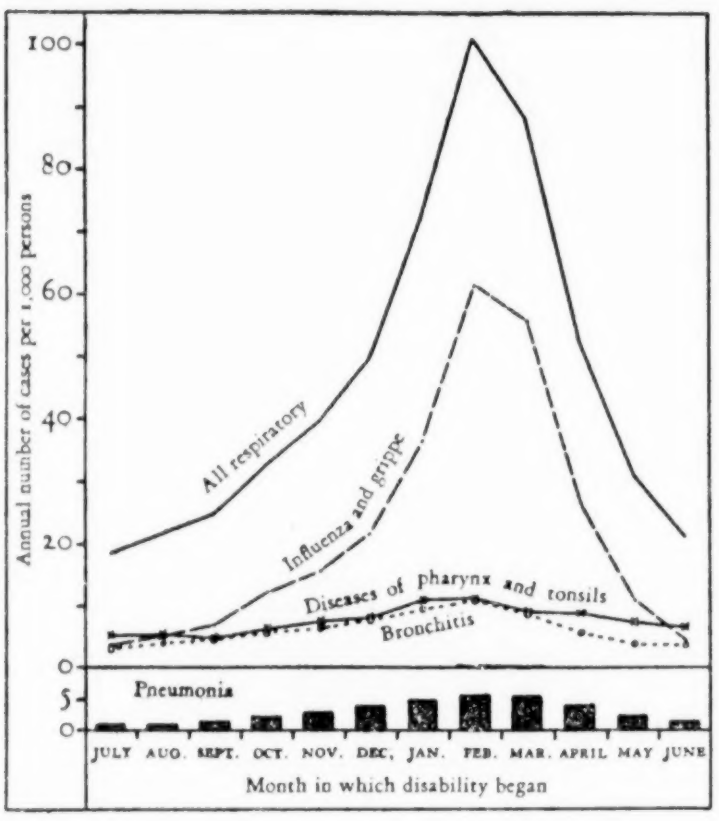

FIG. 3.—Seasonal variations in different types of respiratory diseases, as shown by the average monthly rates for 1921 to 1926, inclusive, in approximately 100,000 wage earners. Only disabilities lasting at least eight days are included. About 10 per cent. of the total number of persons included in the record were women.

FACTORS AFFECTING RATE OF DISABLING SICKNESS

Age

The sickness statistics of industry represent to a surprising extent the younger adult ages. In the manufacturing industries of the country as a whole, probably 80 per cent. of the men are below age 45. This estimate is based on the age distribution of 10,143 men representing ten important industries (4, p. 11). A larger proportion of the female industrial workers, apparently from 90 to 95 per cent., is below age 45.[2]

There is evidence in the age curves of illness that industrial workers are not representative of the general population from a physical standpoint. Rather, they appear to be, in the main, a favorably selected group from a health standpoint. Between 15 and 50, the age curve of illness in a general population group was found to mount more rapidly than in a typical industrial group, as is shown in Figure 6, which accompanies further discussion of this point in the section on "Industrial Selection."

These tendencies have been mentioned to provide a sort of background for presenting the age curves of illness among the male employees of an industry involving fairly heavy work. The age curves shown are based on a record of disabilities from sickness, including nonindustrial accidents, lasting eight calendar days or longer among men employed by a farm implement manufacturing company, the experience being for the five years from 1916 to 1920, inclusive (Fig. 4 and Table 4).

It will be seen from Figure 4 that the frequency or incidence rate of disabilities lasting longer than one week did not vary markedly according to age, at least not prior to age 50. After that age, however, the frequency of sickness mounted fairly

[2] A typical picture of the age distribution of industrially employed males and females is given in (3, Fig. 2).

TABLE 4.—FREQUENCY OF SICKNESS, INCLUDING NONINDUSTRIAL ACCIDENTS, CAUSING DISABILITY FOR MORE THAN ONE WEEK, AND NUMBER OF DAYS LOST FROM WORK ON ACCOUNT OF SUCH CASES, BY AGE, AMONG MALE MEMBERS OF THE EMPLOYEES' BENEFIT ASSOCIATION OF A FARM IMPLEMENT COMPANY

(Experience of employees at the Chicago, Milwaukee, and Akron plants of the company, 1916 to 1920, inclusive)

AGE GROUP	NO. OF YEARS OF LIFE UNDER OBSERVATION	NO. OF CASES	NO. OF DAYS LOST	ANNUAL NO. OF CASES PER 1,000 MALES	ANNUAL NO. OF DAYS LOST PER PERSON	NO. OF DAYS LOST PER CASE
All ages	38,672	6,951	208,081	179.7	5.381	29.9
Under 25	5,578	1,060	22,946	190.0	4.114	21.7
25–34	14,144	2,464	59,218	174.2	4.187	24.0
35–44	9,945	1,760	48,119	177.0	4.839	27.3
45–54	5,115	957	33,253	187.1	6.501	34.7
55 and over	2,906	710	44,545	244.3	15.329	62.7
Unknown	984	0	0	.....	.....	....

rapidly. The number of days lost per man per year rose faster with age than did the frequency of illness. The sole reason for this difference is the longer duration of disability in the higher age groups. In addition to the fact that more serious diseases naturally tend to occur at the later ages, there is some evidence of a definite waning of recuperative ability even in the early thirties. The sickness records of the Edison Electric Illuminating Company of Boston show, for example, a longer average duration of absence on account of diseases of the nasal fossae (mostly head colds) among persons in the thirties than among those in the twenties, and still longer average durations beyond age 40 (3, p. 547).

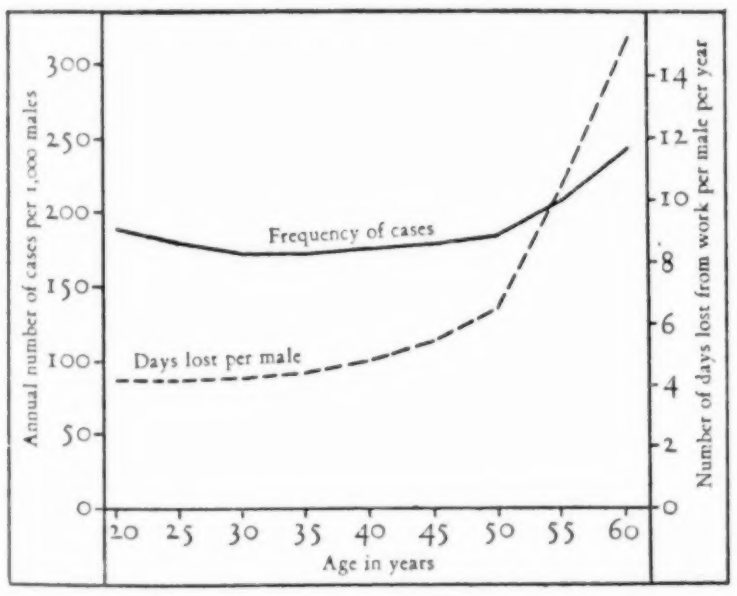

FIG. 4.—A comparison of the *frequency* with the *severity* of sickness at different ages among male members of the Employees' Benefit Association of a farm implement company, 1916 to 1920, inclusive. Only sicknesses lasting eight days or longer are included. Industrial accidents are excluded.

It is apparent that the age distribution of the populations at risk does not require such careful consideration in comparing sickness frequency as is necessary for an equitable comparison of sickness severity rates.

Sex

Female employees tend to be absent on account of illness much oftener than males. Most of the mutual benefit associations reporting to the

TABLE 5.—FREQUENCY OF DISABILITIES LASTING MORE THAN ONE WEEK, ACCORDING TO SEX, 1921 TO 1927, IN A GROUP OF INDUSTRIAL SICK BENEFIT ASSOCIATIONS REPORTING TO THE UNITED STATES PUBLIC HEALTH SERVICE

DISEASES AND CONDITIONS CAUSING DISABILITY	ANNUAL NO. OF CASES PER 1,000		PERCENTAGE OF MALE RATE	NO. OF CASES	
	Males	Females		Males	Females
Sickness and nonindustrial injuries	101.3	151.9	150	74,516	12,232
Sickness (1–164, 205)	91.2	141.4	155	67,089	11,382
External causes (nonindustrial injuries) (165–203)	10.1	10.5	104	7,427	850
Diseases of the respiratory system	42.4	65.4	154	31,201	5,269
Influenza and grip (11)	20.1	25.9	129	14,799	2,089
Tuberculosis of respiratory system (31)	1.5	1.7	113	1,097	139
Bronchitis (acute and chronic) (99)	5.7	8.8	154	4,230	707
Pneumonia (all forms) (100, 101)	3.3	1.5	45	2,433	122
Diseases of the pharynx and tonsils (109)	6.4	17.4	272	4,680	1,401
Other respiratory diseases (97, 98, 102–107)	5.4	10.1	187	3,962	811
Diseases of the digestive system	13.9	20.6	148	10,200	1,655
Diseases of the stomach (111, 112)	4.7	4.5	96	3,463	363
Diarrhea and enteritis (114)	1.7	1.7	100	1,264	133
Appendicitis (117)	3.6	9.5	264	2,660	768
Hernia (118a)	1.6	0.3	19	1,118	25
Other digestive diseases (108, 110, 115, 116, 118b–127)	2.3	4.6	200	1,695	366
Diseases of the circulatory and genito-urinary systems	6.8	9.9	146	5,017	801
Diseases of the heart (87–90)	1.7	1.6	94	1,235	129
Diseases of the veins (93)	1.5	1.0	67	1,121	76
Other diseases of the circulatory system (91, 92, 94–96)	0.9	1.1	122	661	92
Nephritis (acute and chronic) (128, 129)	0.7	0.7	100	553	58
Other diseases of the genito-urinary system and annexa (130–142)	2.0	5.5	275	1,447	446
Diseases of the nervous system (70–84)	4.4	12.0	273	3,272	968
Neuralgia, neuritis, sciatica (82)	2.1	2.6	124	1,526	209
Neurasthenia and the like (part of 84)	1.5	8.8	587	1,129	708
Other diseases of the nervous system (70–81, 83, 84)	0.8	0.6	75	617	51
Rheumatism (acute and chronic) (51, 52)	5.9	3.6	61	4,320	286
Lumbago and other diseases of the organs of locomotion (158)	3.3	1.6	48	2,424	126
Diseases of the skin (151–154)	3.8	3.9	103	2,806	313
Epidemic and endemic diseases (1–10, 12–25)	2.7	4.0	148	1,987	318
All other diseases	8.0	20.4	255	5,862	1,646
Diseases of the eye (85)	1.1	1.6	145	824	126
Diseases of the ear and mastoid process (86)	0.6	1.0	167	414	81
Cancer (all forms) (43–49)	0.6	1.1	183	464	87
General diseases not shown above (26–30, 32–37, 41, 42, 50, 53–69)	2.5	5.8	232	1,832	469
Diseases of the bones and joints (155, 156)	1.0	0.8	80	755	65
Ill-defined and unknown causes (205)	2.2	10.1	459	1,573	818

No. of years of life under observation: males, 735,507; females, 80,523.

Public Health Service pay sick benefits only for ailments common to both sexes; nevertheless, the frequency of disability lasting longer than one week for which sick benefits were paid was 50 per cent. higher over a seven-year period among the female than among the male members of these associations. The higher sickness rate among the women occurred in spite of a more favorable age distribution, for a larger proportion of women than of men in industry is found at the younger ages. Only a small percentage of female industrial employees, as has been shown, is above age 45.

As to the nature of the illnesses causing disability for more than one week in the two sexes, one finds that the rate among the women was more than twice that of the male rate for neurasthenia, diseases of the pharynx and tonsils, appendicitis, the genito-urinary group exclusive of nephritis, for certain general diseases, and for ill-defined and unknown causes. The women, however, experienced a much lower rate of hernia than the men, pneumonia at less than half the male frequency, less rheumatism, fewer cases of lumbago and other diseases of the organs of locomotion, and a frequency considerably below that prevailing among the men for diseases of the veins and diseases of the bones and joints. For most disease groups, however, the female rate was higher than the male rate. The annual number of nonindustrial injuries per 1,000 persons was about the same for either sex. (See Table 5.)

When the record covers absences from work lasting one day or longer, the frequency rate may be as much as 75 to 100 per cent. greater among

TABLE 6.—FREQUENCY OF ABSENCE DUE TO SICKNESS, EXCLUSIVE OF ACCIDENTS, OF SPECIFIED DURATION AMONG EMPLOYEES OF THE EDISON ELECTRIC ILLUMINATING COMPANY OF BOSTON, 1922 TO 1924, INCLUSIVE

DURATION OF ABSENCE IN CALENDAR DAYS[1]	ANNUAL NO. OF ABSENCES PER 1,000		NO. OF ABSENCES	
	Males	Females	Males	Females
All durations	1,044	2,304	6,399	3,475
1 day	316	1,022	1,938	1,541
2 days	225	480	1,377	724
3 days	128	198	782	299
4 days	83	123	509	185
5 days	57	73	351	110
6–8 days	34[2]	57[2]	624	258
9–11 days	12[2]	21[2]	222	95
12 days or more	97	174	596	263

No. of years of life under observation: males, 6,129; females, 1,508.

[1] No. of calendar days intervening between date absence began and date employee returned to work.

[2] Average for period specified.

women than among males, because short disabilities, especially the one, two, and three day cases, tend to occur much oftener among the women, as is shown in Table 6 and Figure 5.

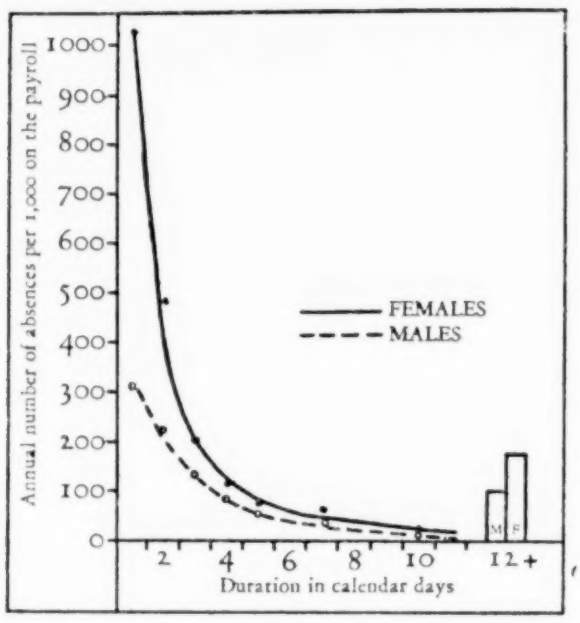

FIG. 5.—Frequency of absences of different durations due to sickness among male and female employees of the Edison Electric Illuminating Company of Boston in 1922 to 1924, inclusive. Industrial and nonindustrial accidents are not included.

Ratios of female to male disability rates based on absences due to sickness lasting one day and longer among employees of the Edison Electric Illuminating Company of Boston are shown in Table 7 for total sickness, and for certain diseases, by age groups. For the female employees of this company, the sickness frequency rate was 2.2 times the male incidence rate. Shorter average duration of cases, however, occurred among the women; nevertheless, the number of days lost on account of sickness per person on the payroll was twice that of the male loss. The widest differences in the sickness rates of the two sexes were found in the age group 15 to 24.

Nationality

Very little information exists concerning racial susceptibility to disease and, more specifically, to certain types of ailments. Among industrial workers it is especially difficult to evaluate the racial or nationality factor in sickness on account of the tendency for persons of the same nationality to engage in similar lines of work and to adopt the living conditions of their countrymen so that what may appear to be racial predisposition to certain diseases may be the effect of occupation or the mode of living.

The only information which appears to be available on this subject that is based on the experience of several thousand men is the tabulated record of the sick benefit association of a large farm implement company covering the five years ending with December, 1920. In the absence of other large collections of morbidity material on the nationality factor, it is presented for what it may be worth.

Unfortunately, the term nationality was not strictly defined in the record for these men. It represents what the employee reported as his nationality when he applied for membership in the relief association. There is some doubt especially as to the meaning of American, but from inquiry it appears that the name applies in the main to white persons born in the United States. In order to avoid, as much as possible, a confusion of the effect of nationality with that of occupation, we have included in Tables 8 and 9 data only for the ages 15 to 34, inclusive, as deleterious effects of occupation, if any such exist, are not often reflected in a high frequency of disability at ages below 35.

A wide difference is shown in the sickness incidence rate of the group of southern Europeans as compared

TABLE 7.—RATIO OF FEMALE TO MALE DISABILITY FOR ONE-DAY AND LONGER CASES AMONG EMPLOYEES OF THE EDISON ELECTRIC ILLUMINATING COMPANY OF BOSTON, 1922 TO 1924

(Male rate = 100)

DISEASE GROUP	ALL AGES	15–24	25–44	45 AND OVER
Sickness, exclusive of accidents:				
Frequency	221	223	214	135
Duration	92	107	100	122
Days lost per person	203	239	215	165
Industrial accidents:				
Frequency	15	16	11	41
Duration	123	98	224	70
Days lost per person	19	15	24	29
Nonindustrial accidents:				
Frequency	123	120	107	176
Duration	69	76	68	119
Days lost per person	85	90	72	209
Influenza and grip (11):				
Frequency	98	109	95	140
Duration	149	157	161	196
Days lost per person	147	168	154	272
Diseases of the nasal fossae (97):				
Frequency	163	154	160	117
Duration	95	100	103	108
Days lost per person	155	154	164	127
Bronchitis (acute and chronic) (99):				
Frequency	141	163	174	56
Duration	183	127	274	184
Days lost per person	255	209	480	103
Diseases of the pharynx and tonsils (109):				
Frequency	263	196	255	196
Duration	92	95	92	82
Days lost per person	242	188	237	158
Diseases of the stomach, diarrhea, enteritis (111, 112, 114):				
Frequency	169	167	163	110
Duration	75	92	72	225
Days lost per person	126	154	118	246
Neurasthenia, etc. (part of 84):				
Frequency	614	538	716	368
Duration	78	169	52	160
Days lost per person	485	899	362	576
Diseases of the skin (151–154):				
Frequency	126	137	104	125
Duration	61	65	71	63
Days lost per person	77	88	74	80
Rheumatism (acute and chronic):				
Frequency	69	138	84	87
Duration	146	82	168	179
Days lost per person	102	113	140	154

with the group from northern and central Europe. It is probable, however, that some confusion has occurred in recording nationality for Americans and for the northern Europeans, as the latter group represents the older immigrants who would be more likely to consider themselves Americans than would the newer immigrants from southern Europe. However, a valid comparison appears to be the sickness rates of the southern Europeans with the average rates for all nationalities combined, since the former comprised only 7 per cent. of the total number of years of life under observation.

The frequency of cases causing disability for more than one week was 38 per cent. higher among the southern Europeans as a group than among all nationalities combined. Respiratory diseases occurred 49 per cent. oftener, but the nonrespiratory diseases as a group showed an excess of only 25 per cent. among the south-

TABLE 8.—FREQUENCY OF SICKNESS, INCLUDING NONINDUSTRIAL ACCIDENTS, CAUSING DISABILITY FOR MORE THAN ONE WEEK AT AGES 15 TO 34, INCLUSIVE, ACCORDING TO NATIONALITY, AMONG MALE MEMBERS OF THE EMPLOYEES' BENEFIT ASSOCIATION OF A FARM IMPLEMENT COMPANY

(Experience of employees at the Chicago, Milwaukee, and Akron plants of the company, 1916 to 1920, inclusive)

NATIONALITY	ANNUAL NO. OF CASES PER 1,000 YEARS OF LIFE	NO. OF CASES	NO. OF YEARS OF LIFE UNDER OBSERVATION
All nationalities	178.7	3,524	19,722
Americans—white (presumably persons born in U. S.)	185.9	1,810	9,735
Northern and central Europeans	166.0	1,266	7,627
Scandinavians	125.0	24	192
Poles	160.2	839	5,237
Russians	165.1	70	424
Germans	184.1	153	831
Austrians	186.9	103	551
All others[1]	196.4	77	392
Southern Europeans	247.3	326	1,318
Serbs, Croats, and Slovenes	213.8	65	304
Hungarians	225.9	89	394
Italians	239.5	74	309
Greeks	330.9	91	275
All others[2]	.....[3]	7	36
Nationality not recorded	.....	70	724
All other nationalities	163.5	52	318

[1] English, Welsh, Scotch, Irish, Dutch, French, Swiss, Czechs, and Lithuanians.
[2] Roumanians and Bulgarians.
[3] Rate not computed when years of life were less than 50.

TABLE 9.—FREQUENCY OF DISABILITY LASTING MORE THAN ONE WEEK AT AGES 15 TO 34, INCLUSIVE, DUE TO SPECIFIED DISEASE GROUPS, ACCORDING TO NATIONALITY, AMONG MALE MEMBERS OF THE EMPLOYEES' BENEFIT ASSOCIATION OF A FARM IMPLEMENT COMPANY

(Experience of employees at the Chicago, Milwaukee, and Akron plants of the company, 1916 to 1920, inclusive)

NATIONALITY	RESPIRATORY DISEASES	TUBERCULOSIS OF LUNGS	PNEUMONIA	INFLUENZA AND GRIP	BRONCHITIS AND TONSILLITIS	OTHER RESPIRATORY DISEASES	DISEASES OF DIGESTIVE SYSTEM	ALL OTHER DISEASES	NONINDUSTRIAL ACCIDENTS
Annual No. of Cases per 1,000 Years of Life									
All nationalities	96.3	2.5	3.6	53.9	22.9	13.4	17.5	52.0	12.9
Americans—white (presumably persons born in U. S.)	97.6	2.7	3.8	55.2	22.6	13.3	16.3	57.3	14.7
Northern and central Europeans	90.3	2.5	3.0	51.0	21.2	12.6	18.5	46.6	10.6
Scandinavians	67.7	...[3]	...[3]	26.0	26.0	....[3]	....[3]	31.2	....[3]
Poles	82.9	2.9	3.1	45.8	18.9	12.2	19.4	48.9	9.0
Russians	108.5	...[3]	...[3]	68.4	16.5	16.5	....[3]	40.1	....[3]
Germans	105.9	...[3]	...[3]	59.0	30.1	13.2	16.8	49.4	12.0
Austrians	112.5	...[3]	...[3]	69.0	25.4	12.7	18.2	39.9	16.3
All others[1]	117.3	...[3]	...[3]	71.4	30.6	....[3]	20.4	33.2	25.5
Southern Europeans	143.4	...[3]	4.6	75.9	37.2	23.5	22.7	64.5	16.7
Serbs, Croats, and Slovenes	115.1	...[3]	...[3]	36.2	49.3	29.6	23.0	69.1	....[3]
Hungarians	129.4	...[3]	...[3]	81.2	27.9	12.7	25.4	53.3	17.8
Italians	145.6	...[3]	...[3]	77.7	35.6	25.9	....[3]	48.5	35.6
Greeks	203.6	...[3]	...[3]	120.0	40.0	29.1	36.4	87.3	....[3]
All others[2]	.....[3]	...[3]	...[3]	....[3]	....[3]	....[3]	....[3]	....[3]	....[3]
Nationality not recorded	.....	...	...	.....	....	....	....	....	....
All other nationalities	94.3	...[3]	...[3]	40.9	28.3	18.9	18.9	37.7	....[3]
No. of Cases									
All nationalities	1,899	50	70	1,063	451	265	346	1,025	254
Americans—white	950	26	37	537	220	130	159	558	143
Northern and central Europeans	689	19	23	389	162	96	141	355	81
Scandinavians	13	0	0	5	5	3	4	6	1
Poles	434	15	16	240	99	64	102	256	47
Russians	46	2	1	29	7	7	3	17	4
Germans	88	0	3	49	25	11	14	41	10
Austrians	62	0	3	38	14	7	10	22	9
All others[1]	46	2	0	28	12	4	8	13	10
Southern Europeans	189	3	6	100	49	31	30	85	22
Serbs, Croats, and Slovenes	35	0	0	11	15	9	7	21	2
Hungarians	51	0	3	32	11	5	10	21	7
Italians	45	1	1	24	11	8	3	15	11
Greeks	56	2	2	33	11	8	10	24	1
All others[2]	2	0	0	0	1	1	0	4	1
Nationality not recorded	41	2	2	24	11	2	10	15	4
All other nationalities	30	0	2	13	9	6	6	12	4

[1] English, Welsh, Scotch, Irish, Dutch, French, Swiss, Czechs, and Lithuanians.

[2] Roumanians and Bulgarians.

[3] Rate not computed when number of cases was less than 5.

ern Europeans. The extent to which they experienced specific respiratory diseases at rates higher than occurred among all nationalities combined is indicated by the following percentages: for pneumonia (all forms) the incidence rate was 28 per cent. higher; for influenza, 41 per cent.; for bronchitis and tonsillitis, 62 per cent.; and for all other respiratory diseases, 75 per cent. Two influenza epidemics of great severity occurred during the period under consideration, and it is seen from Table 9 that the rate of influenza was especially high among the Greeks, Hungarians, and Italians. These results strongly suggest that immigrants from the warm regions of southern Europe may be more liable to attack from the respiratory diseases than are persons who have emigrated from northern Europe or who are native to this country.

Marital Status

The comparisons that have been frequently made of death rates according to marital status cannot be given much importance as an indication of the effect of marital status *per se* unless the individuals are of the same physical constitution and have the same physical status at marriage. The higher mortality among single males at all ages may be due entirely to a selection of more physically fit for marriage. At any rate, until a valid comparison is possible, no definite conclusions can be drawn except possibly from the death rates of the widowed and divorced among both men and women as constrasted with the married and single (5, p. 229).

The sickness rates for married and single wage earners are more comparable than are death rates because all persons are physically able to be employed. The records for men, however, are faulty because it is difficult for the personnel departments to keep accurate records of changes in the marital status of men, and thus far few companies have attempted to record anything more than the marital status of the man at the time he was employed. Changes in the marital condition of women, on the other hand, can be recorded without difficulty on account of the change in name at marriage.

The largest set of industrial morbidity records that can be analyzed according to marital condition among persons of different age, and by causes of disability, was maintained by a rubber company in New England which generously made the data available to the Public Health Service. The record covers absences on account of disability lasting two consecutive working days or longer. Information concerning causes of absence was obtained by visiting nurses who endeavored to call on all absentees on their second day of absence. When the employee was absent on account of sickness, the nature of the illness was recorded, and revisits were made once a week until the sickness terminated. This method appears to have afforded over a period of years fairly satisfactory information concerning the diseases causing disability. Entrance physical exminations were inaugurated at the time the sickness records were started, and a physical rating was given each person in accordance with the impairments found. This policy made it possible to ascertain the proportion of employees who

had serious physical defects in each marital group under comparison.

The physical examination data indicated that a smaller proportion of married than of single women had serious physical impairments (indicated by the rating 3 or 4 in Table 10); nevertheless, the frequency of sickness (including nonindustrial accidents) causing absence for more than one working day was 31 per cent. higher among the married than among the single women on the factory payroll after adjusting the rates to eliminate the effect of age differences (Table 11). The frequency of disabling sickness among the widowed and divorced women was 12 per cent. higher than the rate for the single, but the number of widowed and divorced women on the payroll was not large enough to afford trustworthy conclusions, and they have been omitted, therefore, in most of the tables which follow Table 11.

On account of the length of the period under consideration (eight years), it appeared desirable to find out whether the sickness rates according to marital status changed in any important way during the period. The rates were, therefore, computed for the first three years of the period

TABLE 10.—PHYSICAL RATING OF SINGLE AND MARRIED WOMEN ON THE FACTORY PAYROLL OF A RUBBER COMPANY IN MASSACHUSETTS, 1921 TO 1928, INCLUSIVE

PHYSICAL RATING AND AGE	SINGLE	MARRIED
Percentage		
Under 25	100.0	100.0
Rating 1	52.1	55.6
Rating 2	45.2	42.8
Ratings 3 and 4	2.7	2.2
25-44	100.0	100.0
Rating 1	48.5	47.2
Rating 2	45.3	49.2
Ratings 3 and 4	6.2	3.6
No. of Years of Life under Observation		
Under 25	6,153	1,216
25-44	2,309	4,053

TABLE 11.—FREQUENCY OF ABSENCE DUE TO SICKNESS AND NONINDUSTRIAL ACCIDENTS CAUSING DISABILITY FOR TWO CONSECUTIVE WORKING DAYS OR LONGER AMONG WOMEN ON THE FACTORY PAYROLL OF A RUBBER COMPANY IN MASSACHUSETTS, 1921 TO 1928, INCLUSIVE, ACCORDING TO MARITAL STATUS

MARITAL STATUS	NO. OF YEARS OF LIFE UNDER OBSERVATION	NO. OF ABSENCES	ANNUAL NO. OF ABSENCES PER 1,000 WOMEN	RATE ADJUSTED TO ELIMINATE AGE DIFFERENCES	RATIO TO RATE FOR SINGLE WOMEN
All marital conditions	15,121	9,487	627	...	...
Single	8,843	4,760	538	556	100
Widowed and divorced	604	393	651	624	112
Married	5,672	4,326	763	730	131
Unknown	2	8	...	...	...

as compared with the next five. Much lower incidence rates are indicated in 1924 to 1928 than in the preceding years, but relative differences in the rates according to marital status changed very little. After the incidence rates were adjusted to eliminate age differences, disabling illness was found to occur 30 per cent. oftener among the married than among the single in 1924 to 1928, and 35 per cent. oftener in 1921 to 1923. The results for the widowed and divorced women were remarkably consistent in the two periods, in view of the small number of such persons.

An incidence rate based on cases of disability lasting two working days or longer obviously includes minor as well as serious illnesses; and, in view of the possibility that the higher incidence rate of the married might be due merely to a higher frequency of absence for minor ailments, it seemed advisable to ascertain the severity of sickness in the two groups by means of frequency rates for cases of different durations. As is shown in Table 12, among women under 25 years of age, the frequency of two and three day disabilities among the married was 27 per cent. above the corresponding rate for the single; for disabilities lasting four to six working days, an excess of 66 per cent. was indicated for the married; and for disabilities lasting seven working days and longer (more than one week) the rate among the married was 72 per cent. above that among the single. In the age group 25 to 44, the frequency of two and three day disabilities was 18 per cent. higher among the married than among the

TABLE 12.—FREQUENCY OF DISABILITY DUE TO SICKNESS AND NONINDUSTRIAL ACCIDENTS OF SPECIFIED DURATION AMONG THE SINGLE AS COMPARED WITH THE MARRIED WOMEN ON THE FACTORY PAYROLL OF A RUBBER COMPANY IN MASSACHUSETTS, 1921 TO 1928, INCLUSIVE

DURATION OF ABSENCE IN WORKDAYS	ANNUAL NO. OF DISABILITIES PER 1,000 YEARS OF LIFE				PERCENTAGE IN EXCESS OF RATE FOR SINGLE		NO. OF DISABILITIES			
	Under 25		25–44				Under 25		25–44	
	Single	Married	Single	Married	Under 25	25–44	Single	Married	Single	Married
All durations	529	820	564	757	55	34	3,358	1,022	1,347	3,162
2–3 days	183	233	164	194	27	18	1,160	290	391	808
4–6 days	145	240	136	211	66	55	919	299	324	883
7 days or more	201	346	264	352	72	33	1,279	432	632	1,471
Unknown	...	1	...	...	..	..	0	1	0	0
No. of years of life under observation	...	...	...	...	..	..	6,343	1,247	2,388	4,179

An incidence rate based on cases of disability lasting two working days or longer obviously includes minor as well as serious illnesses; and, in view of the possibility that the higher incidence rate of the married might be due merely to a higher frequency of absence for minor ailments, it seemed advisable to ascertain the severity of sickness in the two groups by means of frequency rates for cases of different durations. As is shown in Table 12, among women under 25 years of age, the frequency of two and three day disabilities among the married was 27 per cent. above the corresponding rate for the single; for disabilities lasting four to six working days, an excess of 66 per cent. was indicated for the married; and for disabilities lasting seven working days and longer (more than one week) the rate among the married was 72 per cent. above that among the single. In the age group 25 to 44, the frequency of two and three day disabilities was 18 per cent. higher among the married than among the

single; for the four to six day cases, the rate was 55 per cent. higher among the married; and disabilities of more than one week's duration were experienced one-third oftener by the married. If the duration of absence may be considered a criterion of severity, the married women fared much worse than the single women in number of serious cases. Especially was this so among the married at ages below 25.

The next query naturally relates to the nature of the ailments to which the married women appeared to be more susceptible than the single women. What disease groups and specific diseases attacked the married more frequently than the single at the same ages? Three broad disease groups were first considered, *i.e.*, the respiratory, the digestive, and all other diseases as a whole. Table 13

TABLE 13.—FREQUENCY OF ABSENCE DUE TO SPECIFIED DISEASE GROUPS AMONG THE SINGLE AS COMPARED WITH THE MARRIED WOMEN ON THE FACTORY PAYROLL OF A RUBBER COMPANY IN MASSACHUSETTS, 1921 TO 1928, INCLUSIVE

MARITAL STATUS	ANNUAL NO. OF ABSENCES PER 1,000 WOMEN ON PAYROLL				NO. OF ABSENCES			
	Under 25		25–44		Under 25		25–44	
	2–6 Workdays	7 Workdays or Longer	2–6 Workdays	7 Workdays or Longer	2–6 Workdays	7 Workdays or Longer	2–6 Workdays	7 Workdays or Longer
Sickness Including Nonindustrial Accidents								
Single	328	202	299	265	2,080	1,277	715	632
Married	474	347	405	352	590	432	1,691	1,471
Percentage + or − rate for single	+44	+72	+35	+33	.....	.....	.....	.....
Diseases of the Respiratory System[1]								
Single	162	87	141	102	1,029	551	337	243
Married	237	144	181	137	295	179	754	571
Percentage + or − rate for single	+46	+66	+28	+34	.....	.....	.....	.....
Diseases of the Digestive System[2]								
Single	44	23	47	25	279	144	112	60
Married	62	40	55	39	77	50	230	164
Percentage + or − rate for single	+41	+74	+17	+56	.....	.....	.....	.....
All Other Diseases								
Single	122	92	111	138	772	582	266	329
Married	175	163	169	176	218	203	707	736
Percentage + or − rate for single	+43	+77	+52	+28	.....	.....	.....	.....

[1] Title numbers 11, 31, 97–107, and 109 in the International List of the Causes of Death.
[2] Title numbers 108, 110–127.

TABLE 14.—FREQUENCY OF ABSENCE DUE TO SPECIFIED CAUSE AMONG THE SINGLE AS COMPARED WITH THE MARRIED WOMEN ON THE FACTORY PAYROLL OF A RUBBER COMPANY IN MASSACHUSETTS, 1921 TO 1928, INCLUSIVE

MARITAL STATUS	ANNUAL NO. OF ABSENCES PER 1,000 WOMEN ON PAYROLL				NO. OF ABSENCES			
	Under 25		25–44		Under 25		25–44	
	2–6 Workdays	7 Workdays or Longer	2–6 Workdays	7 Workdays or Longer	2–6 Workdays	7 Workdays or Longer	2–6 Workdays	7 Workdays or Longer
Influenza and Grip (11)								
Single	47	34	39	50	298	218	94	119
Married	83	61	66	70	103	76	275	293
Percentage + or − rate for single	+77	+79	+69	+40	...	...	...	...
Diseases of the Nasal Fossae (97)								
Single	53	11	59	22	334	70	141	53
Married	87	31	73	22	109	39	305	92
Percentage + or − rate for single	+64	+182	+24	0	...	...	...	...
Diseases of the Pharynx and Tonsils (109)								
Single	45	28	25	18	288	175	59	42
Married	46	27	27	20	57	33	111	84
Percentage + or − rate for single	+2	−4	+8	+11	...	...	...	...
Other Respiratory Diseases[1]								
Single	17	14	18	12	109	88	43	29
Married	21	25	15	25	26	31	63	102
Percentage + or − rate for single	+24	+79	−17	+108	...	...	...	...
Diseases of the Stomach, Diarrhea, Enteritis (111, 112, 114)								
Single	22	6	34	10	137	35	82	25
Married	39	18	40	23	48	23	167	98
Percentage + or − rate for single	+77	+200	+18	+130	...	...	...	...
Other Diseases of the Digestive System[2]								
Single	22	17	13	15	142	109	30	35
Married	23	22	15	16	29	27	63	66
Percentage + or − rate for single	+5	+29	+15	+7	...	...	...	...
Rheumatism and the Myalgias (51, 52, 158)								
Single	11	8	12	17	70	49	29	41
Married	21	11	29	29	27	14	123	122
Percentage + or − rate for single	+91	+38	+142	+71	...	...	...	...

TABLE 14.—*Concluded*

MARITAL STATUS	ANNUAL NO. OF ABSENCES PER 1,000 WOMEN ON PAYROLL				NO. OF ABSENCES			
	Under 25		25–44		Under 25		25–44	
	2–6 Workdays	7 Workdays or Longer	2–6 Workdays	7 Workdays or Longer	2–6 Workdays	7 Workdays or Longer	2–6 Workdays	7 Workdays or Longer
Diseases of the Nervous System[3]								
Single	6	5	7	14	39	35	18	33
Married	9	6	11	10	11	8	47	43
Percentage + or − rate for single	+50	+20	+57	−29	...	...	...	...
Diseases of the Genital Organs (137–142)								
Single	17	5	15	10	107	30	36	24
Married	34	35	20	26	42	43	83	110
Percentage + or − rate for single	+100	+600	+33	+160	...	...	...	...
Ill-Defined and Unknown Causes of Disability (205)								
Single	32	25	34	51	200	156	81	122
Married	40	41	47	47	50	51	197	195
Percentage + or − rate for single	+25	+64	+38	−8	...	...	...	...
All Other Diseases								
Single	56	49	43	46	356	312	102	109
Married	71	70	62	64	88	87	257	266
Percentage + or − rate for single	+27	+43	+44	+39	...	...	...	...

[1] Bronchitis (acute and chronic), diseases of the larynx, pneumonia, asthma, etc. (title numbers 98–107 in the International List of the Causes of Death).

[2] Diseases of the mouth and annexa, appendicitis, diseases of the liver, etc. (title numbers 108, 110, 115–127).

[3] Exclusive of diseases of the organs of special sense (eyes, ears). Includes title numbers 70–84.

shows no concentration of the excess sickness experienced by the married in any one of these three disease groups. For example, in disabilities lasting two to six working days among those under 25 years of age, the rate for the married was 46 per cent. above that of the single in the respiratory group, 41 per cent. in the digestive group, and 43 per cent. in all other diseases as a whole; while for disabilities of more than one week's duration, the rate among the married exceeded that of the single by 66, 74, and 77 per cent., respectively.

Diseases within these three broad groups are considered in Table 14. The married women appear to have been disabled considerably oftener than the single by influenza and grip

and by diseases of the nasal fossae, but experienced about the same frequency of diseases of the pharynx and tonsils as the single. In the digestive group of diseases, the excess sickness among the married was largely concentrated in diseases of the stomach, diarrhea, and enteritis. Among nonrespiratory, nondigestive diseases, the frequency of rheumatism and the myalgias was considerably higher among the married in each of the two age groups studied. Not so definite were the results for diseases of the nervous system, on account of the small number of cases involved. One of the widest differences indicated was for diseases of the genital organs, the rate being much higher among the married, especially for the more serious cases, *i.e.*, those causing absence for more than one week. Among the married under age 25 there was marked contrast in this respect with the rates for the single.

The reasons for these consistently higher rates among the married obviously cannot be pointed out as precisely as one can state the differences in the rates themselves. It is quite probable, however, that the double duty of the married industrial worker, *i.e.*, the factory job in addition to the homekeeping job involving as it frequently does the strain of childbearing and the care of children as well as the housework itself, may result in overwork sufficient to predispose to illness of any nature, and may thereby exact a toll of incapacitation much greater than that experienced by the single woman in industry.

(*To be concluded*)